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Protocol for Establishment of a Ground Water Management and Protection Plan

Association of Central Oklahoma Governments
Oklahoma City

Prepared for

Robert S. Kerr Environmental Research Lab.
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PROTOCOL FOR ESTABLISHMENT OF A GROUND WATER MANAGEMENT AND PROTECTION PLAN

by

The Association of Central Oklahoma
Council of Governments

CR-807131

Project Officer

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FOREWORD

The Environmental Protection Agency was established to coordinate administration of the major Federal programs designed to protect the quality of our environment.

An important part of the Agency's effort involves the search for information about environmental problems, management techniques, and new technologies through which optimum use of the Nation's land and water resources can be assured and the threat pollution poses to the welfare of the American people can be minimized.

EPA's Office of Research and Development conducts this search through a nationwide network of research facilities.

As one of these facilities, the Robert S. Kerr Environmental Research Laboratory is the Agency's center of expertise for investigation of the soil and subsurface environment. Personnel at the laboratory are responsible for management of research programs to: (a) determine the fate, transport and transformation rates of pollutants in the soil, the unsaturated zone and the saturated zones of the subsurface environment; (b) define the processes to be used in characterizing the soil and subsurface environment as a receptor of pollutants; (c) develop techniques for predicting the effect of pollutants on ground water, soil and indigenous organisms; and (d) define and demonstrate the applicability and limitations of using natural processes, indigenous to the soil and subsurface environment, for the protection of this resource.

This report contributes to that knowledge which is essential in order for EPA to establish and enforce pollution control standards which are reasonable, cost effective, and provide adequate environmental protection for the American public.

Clinton W. Hall

Clinton W. Hall
Director
Robert S. Kerr Environmental
Research Laboratory

ABSTRACT

Local officials can provide the impetus for the establishment of a management program for water-supply aquifers. This report provides information on the development of a management plan for a specific aquifer in Oklahoma. The report outlines specific major steps that were taken to accomplish the task. The approach should be transferable to other areas of the country.

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INTRODUCTION

In recent years, many areas of the country have begun to experience major problems with their ground-water resources. The most notable problems are: pollution, overdraft or mining, subsidence, and salt-water intrusion.

Not enough research has been done, however, to adequately mitigate these problems and to develop a systematic method for managing ground-water resources. In an effort to protect a local ground-water supply and to provide an approach for effective management of ground-water resources nationwide, the Association of Central Oklahoma Governments has established protocol for development of a management plan (including a development and protection strategy).

The members of the Association of Central Oklahoma Governments (a Council of Governments serving the Oklahoma City metropolitan area), through a subentity referred to as the Garber-Wellington Association developed the protocol as a product of their research on the Garber-Wellington Aquifer, a major ground-water supply in central Oklahoma on which they depend.

The aquifer serves as the primary municipal water supply for 24 cities and towns in addition to hundreds of industrial and private users. Approximately 400,000 people depend on the aquifer for municipal, industrial, domestic and agricultural water supplies.

This document is designed to acquaint the reader with the steps taken by this group of mayors, councilmembers and county commissioners to establish a management program for the aquifer. It is intended to provide enough information to aid local elected officials and professional staff in other parts of the country in the development of management and protection methodologies for aquifers within their jurisdictions. The report format will outline major steps to be taken with more specifics included in the Appendices. The steps are not necessarily chronological, rather some may be addressed simultaneously.

STEP 1: ASSEMBLE THE PARTICIPANTS

The local government officials in central Oklahoma determined that successful implementation of an effective ground-water management program depends upon a high degree of plan involvement by those who benefit from the resource.

It is the beneficiaries, the local owners of the resource, whose futures depend upon continued availability of good quality ground water regardless of whether the use is agricultural, domestic, municipal or industrial. Every entity that utilizes or has the potential to utilize a particular aquifer needs to be identified and involved in development and implementation of the management plan.

The structure established in the Garber-Wellington Project included activation of a policy committee composed of local elected officials of communities/counties that use the aquifer and a technical committee of engineers, water works directors, city managers and other related staff people of the municipalities and counties involved. A copy of the resolution creating these committees and outlining their functions and responsibilities is included in Appendix I. These committees guided the activities of the research staff, and as individual municipal staff members, were responsible for implementation of several of the management components as they surfaced, such as implementation of a water well records keeping system.

Citizens and state and local agencies with an interest in development of the Garber-Wellington Aquifer were also included throughout the planning process through representation on the technical committee, media coverage, distribution of a monthly newsletter about the project and presentations to numerous civic organizations.

Identifying participants is an ongoing process. All local people and organizations with a vested interest in the water supply should be kept informed and involved to the maximum degree possible throughout the development of a plan.

STEP 2: ESTABLISH MEANS FOR PLAN DEVELOPMENT

As alluded to previously, the responsibility for developing a management plan for the Garber-Wellington Aquifer was assumed by a group of local elected officials who formed a project policy committee. In this case, a professional staff was retained to actually perform the work to be reviewed and interpreted by the policy group. The staff for this project included a hydrologist, data management specialist and a secretary in addition to part-time administrative and public participation support staff. Whether this professional staff is contracted or hired directly, a method for generation of revenues to support research and ongoing management must be identified. Examples of such revenue sources are local member dues assessments, water use fees, loans, grants or a combination of the above. The ultimate decision on where to procure funds rests with the beneficiaries.

STEP 3: DEFINE PHYSICAL CHARACTERISTICS

The first objective for the project was to define the physical characteristics of the aquifer. An adequate historical and current data base is critical to identification of all internal factors which can affect an aquifer.

The general goal was to develop a computerized data base to be used in evaluation of the ground-water system.

The information examined included:

Hydrologic parameters of the aquifer.
Delineation of recharge areas.

Historical, current and project water levels.
Chemical quality parameters.
Annual water consumption of all users.
Legal factors affecting management of the basin.

Following are five basic steps involved within this overall component of defining physical characteristics.

(1) Compile Historical Data

Detailed information was assembled from the U.S. Geological Survey; Oklahoma Geological Survey; Oklahoma Water Resources Board; the Oklahoma Corporation Commission; municipal files; Oklahoma State Department of Health; and the technical consultant to the project, Engineering Enterprises, Inc. All existing information on the aquifer was collected and translated into compatible forms to be included in the ACOG/GWA Data Management System.

The Data Management System information was indexed in 10 separate categories to expedite manipulation and retrieval (see Appendix II). This categorical information was stored on a 64K microcomputer. Several microcomputers were researched by ACOG/GWA in an effort to test low cost, low maintenance equipment for its application to ground water management activities. The result was the purchase of a 64K-Intertech Data System Superbrain microcomputer, which utilizes dual disk drives and single sided double density 5 1/4 inch floppy diskettes, coupled with a NEC Spinwriter Printer terminal. Several software packages are available including some with graphics capabilities.

All well information entries were listed by township, range, section and location in order to specify particular areas to examine with a minimum of data manipulation. Each township and range was contained on a separate diskette to minimize turnaround time when only small areas or a single well were examined. This effectively eliminated disk overloading and facilitated adding new information or deletion of duplicate records without searching through the entire data base for a single record. This Data Management System is the single most complete source of information on the aquifer and was the first essential step toward effective management of this resource.

(2) Establish Method for Obtaining Present/Future Data

After the historic data was computerized, researchers plotted the aquifer areally so that they could identify areas where data was lacking. A plan for procuring the necessary information was developed and implemented which included selection of locations for test holes, monitoring wells and electric logging. The most critical component of the plan for obtaining more information, however, was the implementation of a water well records keeping system. A detailed description of the system is provided in Appendix III.

The records keeping system, and related documentation provided the cities and towns involved in the study with a uniform means to collect data on their municipal water wells and feed necessary information into the data system. A key advantage was a tremendous cost savings realized by the municipalities through close monitoring of their well fields, charting of well efficiencies and elimination of major breakdowns through early problem detection. Through this regular monitoring system, significant electrical cost savings have been realized and "downtime" of wells can be better controlled.

The study consultants and ACOG/GWA staff held training sessions to introduce municipal personnel to the records keeping system. Individuals with private wells who expressed concerns about the performance of their individual wells have also been acquainted with the system. ACOG/GWA is collecting data on water levels, water quality, water use and well efficiency on a monthly or bi-monthly basis on over 200 municipal and industrial wells in the region. Many of these wells have been modified to enable personnel to more efficiently collect necessary data, thus encouraging regular and timely data recording.

Most municipalities have allocated funds for modification of existing wells to provide accurate data. New construction is being completed in adherence to the specifications included in the records keeping system packet. The study participants determined that with an accurate accounting by the major municipal and industrial ground-water users, the limited production data from domestic well users would not significantly affect the definition of the aquifer's physical characteristics or future management decisions.

Other means for obtaining current information about the Garber-Wellington Aquifer included the development and adoption of a municipal ordinance (Appendix IV) designed to protect the aquifer from contamination associated with oil and gas activities (a highly ranked potential pollution problem). The ordinance requires oil companies to provide information on the location of the saltwater/freshwater interface. Data on proposed and completed oil and/or gas wells are maintained in the Data Management System.

Five monitoring wells were drilled in key locations where historic data was lacking to ascertain water levels, water quality and the freshwater/saltwater interface. The wells are monitored on a regular basis (bi-monthly) to obtain necessary information from those locations.

(3) Locate Water Quality Problems

A critical element in the evaluation of the physical characteristics of an aquifer is the definition of natural or background water quality. The availability of water is of little importance unless the water is of a quality suitable to meet the user's requirements.

Historic water quality data on the Garber-Wellington Aquifer was collected throughout the initial data search.

After all existing water quality data was entered into the Data Management System, a major sampling effort was conducted to determine current conditions. The initial parameters evaluated were pH, specific conductance, total hardness sulfates and chlorides. These constituents were selected so that background water quality could be established. Changes in water quality would generally be noted by a change in one or more of these parameters.

Analysis for chromium, selenium, arsenic, barium, gross alpha and uranium were then examined for areas exhibiting other than average specific conductance and pH.

One-hundred fifty samples were collected from municipal wells throughout the aquifer, and the results were entered into the computer Data Management System. Although the water quality of the aquifer had been thought to be very good, the sampling efforts revealed in certain wells the existence of chromium, selenium and arsenic in excess of Environmental Protection Agency standards and uranium at levels above "proposed" standards. Fifty percent of the wells tested were producing water in excess of the proposed standard for uranium (see Appendix V).

Various methods for mitigating these problems have been and continue to be explored including (1) mixing poor quality water with better quality water in the distribution system, (2) reconstruction of wells to cut off infiltration from problem zones, (3) abandonment of a few wells, (4) reassessment of standards based on more current data, and (5) research on potential treatment processes.

Each ground-water resource will have its own natural water quality characteristics. The point is that determination of those characteristics is critical to the development of a management plan and possible problem areas should be identified early in the study process.

(4) Identify Pollution Potential

Once naturally occurring sources of water quality degradation are located, one must identify past, present and future human activities that could negatively affect the water quality of the aquifer.

Major potential threats to ground-water quality identified by the National Center for Ground Water Research (NCGWR), included past present and future oil field activities such as the proliferation of pits, ponds, lagoons and other surface and subsurface disposal practices.

Other possible pollution sources were examined including runoff resulting from increased urban expansion, development near or over recharge areas and wastewater discharge. A complete inventory of all surface and subsurface activities was performed and a ranking system developed to determine where the greatest threats existed to the aquifer.

This pollution potential priority system, when combined with area land use and other development plans, will help to ensure that future threats to water resources are minimized. For example, future development in critical recharge areas can be minimized through proper zoning requirements which can incorporate open space development, preservations of natural habitat and/or use of storm water detention facilities, thus, preserving recharge capacities to the aquifer.

New methods for avoiding potential pollution or dealing with existing pollution need to be sought and tested throughout development of a management plan, then incorporated into the plan and its implementation.

(5) Utilize Applicable Available Technologies to Make Your Job Easier and Save Money

There have been several technological advances in the past few years that can help ground-water managers perform the tasks described above. Although the following list is not all inclusive, the items discussed were identified in the Garber-Wellington Research Study and can provide the reader with some idea of technologies available.

Acoustical Well Probe--

An acoustical well probe is an innovative, relatively inexpensive device (less than $1,000) for testing depths to water. The probe uses sound waves to measure the distance between land surface and the standing water level in the well. Although the readings are not accurate enough to use in aquifer tests, the instrument offers excellent capability for rapid water-level measurements on reconnaissance operations.

Inflatable Packer Pumping System--

The inflatable packer pumping system can be utilized to sample specific zones within the formation. This would be particularly helpful when trying to identify areas of possible water quality problems prior to completion of a new well. A single well installed and rigged with the system costs approximately $150,000, but the packer system could be used on other wells once it is built to specifications.

Slow-Start Pump Motor--

There is a relatively new energy saving, slow-starting motor device on the market that can help water well owners, including municipalities, save on energy costs associated with water well pump motors. The unit is designed to slow-start electric motors so that high cost energy peaks are eliminated, thus saving electrical pumping costs. Escalating electrical costs are becoming a major consideration to ground-water users.

Dual Wall Reverse Circulation Drilling Technique--

While this procedure has been around for some time, its applications to ground-water investigation has only recently been realized. The methods employed allow for individual zones of a particular aquifer to be sampled while the initial test hole is under construction. Since no drilling mud or additives are utilized, only formation water is produced. Some primary filtration of water samples is required after collection to remove suspended sediment, however, excellent representative samples can be obtained with this method.

Multiple Construction of Monitoring Wells--

By drilling test holes in a manner such that multiple piezometers can be installed, substantial information can be obtained utilizing a single bore hole. In deep aquifers, for instance, information can be acquired on initial water levels, water quality in several zones and saltwater upconing with a single test hole utilizing multiple construction techniques.

Remote Water Well Sensors--

Current advances in micro-chip technology have led to development of numerous devices designed to give continuous readouts and recording of static and pumping water levels in wells. These devices can be utilized to gather significant amounts of data over short or long periods. Instruments are available now that can be utilized for continuous monitoring of water levels during aquifer pumping tests thereby reducing the potential for interpretation error.

STEP 4: DETERMINE PRESENT AND FUTURE DEMANDS ON THE AQUIFER

A critical component of a management plan is how to ensure that present use of the resource does not endanger the aquifer's potential as a viable water supply in the future. To accomplish this, it is necessary to determine how much water is being withdrawn, how much is being replenished (recharged) (see Appendix VI) and the effects current and projected pumping activities may have on the hydrologic balance of the water basin.

Records on past use, present use data (from the municipal records keeping system), projected population figures and per capita water use estimates will help researchers make some realistic estimates on present and projected demands on the aquifer. Coupled with scientific estimates of basin wide, and specific area safe yield rates (how much water can be withdrawn safely from each area of the aquifer without upsetting its hydrologic balance), this information can help determine whether or not the aquifer can meet demands.

Pumping may need to be limited in some areas of the aquifer to avoid a hydrologic imbalance of the system as a whole (such as upconing of saltwater or lowering of the water table). Such a finding would naturally need to be addressed in a management plan. If more water is being withdrawn than is being replenished, then the aquifer is being mined and the beneficiaries are faced with another potentially serious situation to be addressed.

The management plan should also take into account the availability of surface water supplies and how these resources may be intermingled with the ground-water resources to provide the most efficient utilization of both.

Through continual accumulation of water well information, current and projected water demands should be compared regularly to the physical capabilities and vulnerabilities of the aquifer.

STEP 5: SELECT AN APPROPRIATE COMPUTER MODEL FOR DATA MANIPULATION

Computer models are useful tools for simulating characteristics of an aquifer and how certain activities can impact the aquifer (such as the addition of a number of high volume water wells in a particular location). By calibrating the model (making it duplicate the aquifer's characteristics and how the aquifer has reacted to certain situations in the past), you can impose new situations on the model and get an idea of how the aquifer would react.

A suitable ground-water model or series of models should be able to translate the mathematical results back to the physical conditions existing in the ground-water system with an acceptable degree of accuracy.

An example of the types of questions a model might answer to help in development of a management plan would be: If a city currently has 15 municipal wells pumping 200 gallons of water per minute to meet the demands of 20,000 people, what will be the effect on the water table and well efficiencies of an addition of 10 more wells when the city well field will need to supply water for a population of 30,000 people? The model will enable you to more accurately predict whether or not the aquifer will be able to naturally meet the future demand on a local and regional basis, how to properly space and construct the wells to most efficiently produce the amount of water needed and whether artificial recharge or other alternatives may be required.

There are several ground-water models available including ones that can be used on main frame computers, mini-computers or micro-computers. The type of model that is appropriate depends upon the computer capacities available and the type of ground-water system to be modeled. Information about ground-water models can be obtained through The International Ground Water Modeling Center, Holcomb Research Institute, Butler University, Indianapolis, Indiana 46208.

Once future demands on the aquifer are projected, the model can help with the decision-making involved in the development of a management and protection plan.

STEP 6: DEFINE LEGAL PARAMETERS AND INTERGOVERNMENTAL RESPONSIBILITIES

Oklahoma has been referred to as a "riparian doctrine" state because water laws maintain the rights of riparian owners (owners of land adjacent to water) to utilize the waters that exist on or beneath their property. Current ground-water law not only provides land owners with equal and proportionate shares of the water, it placed municipal, industrial, farming, domestic and commercial use of ground water on equal footing by failing to appropriate ground water based on prioritized beneficial uses. (See Appendix VII).

Each state and the municipalities within that state operate under a unique set of state and local statutes that dictate different jurisdictional responsibilities and authorities. Before a viable management plan can be established the beneficiaries must determine what legal authorities they have to the plan and identify any legal barriers that may exist.

In the case of the Garber-Wellington Project, some of these existing local authorities were identified and exercised even before completion of a management plan. As noted previously in this report, a major potential pollution factor identified was the abundance of oil and gas drilling activity throughout the aquifer area. Through the GWA, the municipalities and counties developed an oil and gas ordinance designed to enable them to exercise some control over such activity occurring in their individual jurisdictions. The ordinance adopted wholly or in part by several of the local governments, establishes permitting and inspection procedure for oil and gas exploration ventures as well as production activities.

Potential threats to the aquifer do not always come from "outside" commercial or individual activities. Realizing that the municipalities that utilize the resource can be their own worst enemy if they do not monitor the cumulative effects of their activities in the aquifer, the Garber-Wellington beneficiaries applied their extensive monitoring system and compilation of data to methods for policing their own activities, also. Municipal utilization of the aquifer must be self regulated and specifically provided for in the management plan. State and federal regulatory authorities over municipal activities, specifically provisions for safe drinking water, can be utilized as an assurance of local government's success with self regulation.

Local governments generally have the authority to monitor and regulate urban expansion, development within recharge areas, wastewater discharge and public services--all factors that need to be addressed in a management plan.

Results from the Garber-Wellington Research Project indicate that local control of a resource is an essential element for assurance that a management plan is implementable and that efficient enforcement of regulations can be accomplished. A local entity that is a beneficiary is more inclined to ensure compliance with local regulations than is a more remote federal or state agency. This does not imply, however, that federal and state involvement in ground-water protection is not necessary. To the contrary, preservation of these resources is of vital concern on a national basis. Federal and state research efforts are particularly needed. It is to suggest that ground-water management belongs at the local level and that federal and state governments' efforts should be supportive of local decisions and should become primary only if it is concluded that the local beneficiaries are unwilling or unable to manage their ground-water resources. The primary rationale for local control is simply that the beneficiaries of the aquifer have the most to lose if the system is ineffective and the most to gain if ground-water management is successful.

The development of local ground-water districts/associations composed of the beneficiaries of an aquifer, whose boundaries generally coincide with defineable hydrogeologic units which encompass underground reservoirs and their recharge areas, was found to be a logical place to begin the management process.

STEP 7: PREPARE MANAGEMENT PLAN

The previous discussion provides a list of the major steps to be taken toward the development of an aquifer protection and management plan; identification of participants, establishment of means to finance plan development, definition of the physical characteristics of the aquifer, selection of a computer model for data manipulation and definition of legal parameters and responsibilities.

These steps seem rather straightforward, however, within completion of each component, you are likely to encounter unexpected situations that will require additional work in certain areas. For example, during collection of data on the Garber-Wellington Aquifer, possible problems with excessive levels of chromium, selenium and uranium were discovered, which prompted additional water quality research.

After each of these steps has been studied and all questions answered to the satisfaction of the beneficiaries, a plan for the use, protection and management of the resource can be written. At this writing, such a plan has not been completed for the Garber-Wellington Aquifer due to several remaining questions such as: What is the actual recharge rate, and is artificial recharge a viable option in this aquifer? How can the policy makers mitigate problem situations caused by overpumpage in certain areas? How can excessive levels of chromium, selenium and uranium be avoided? Research will continue until these questions and others are answered to the satisfaction of the participants.

Once the basic data is compiled, a plan for the use, protection and management of the aquifer will be completed and implemented. It will include such components as:

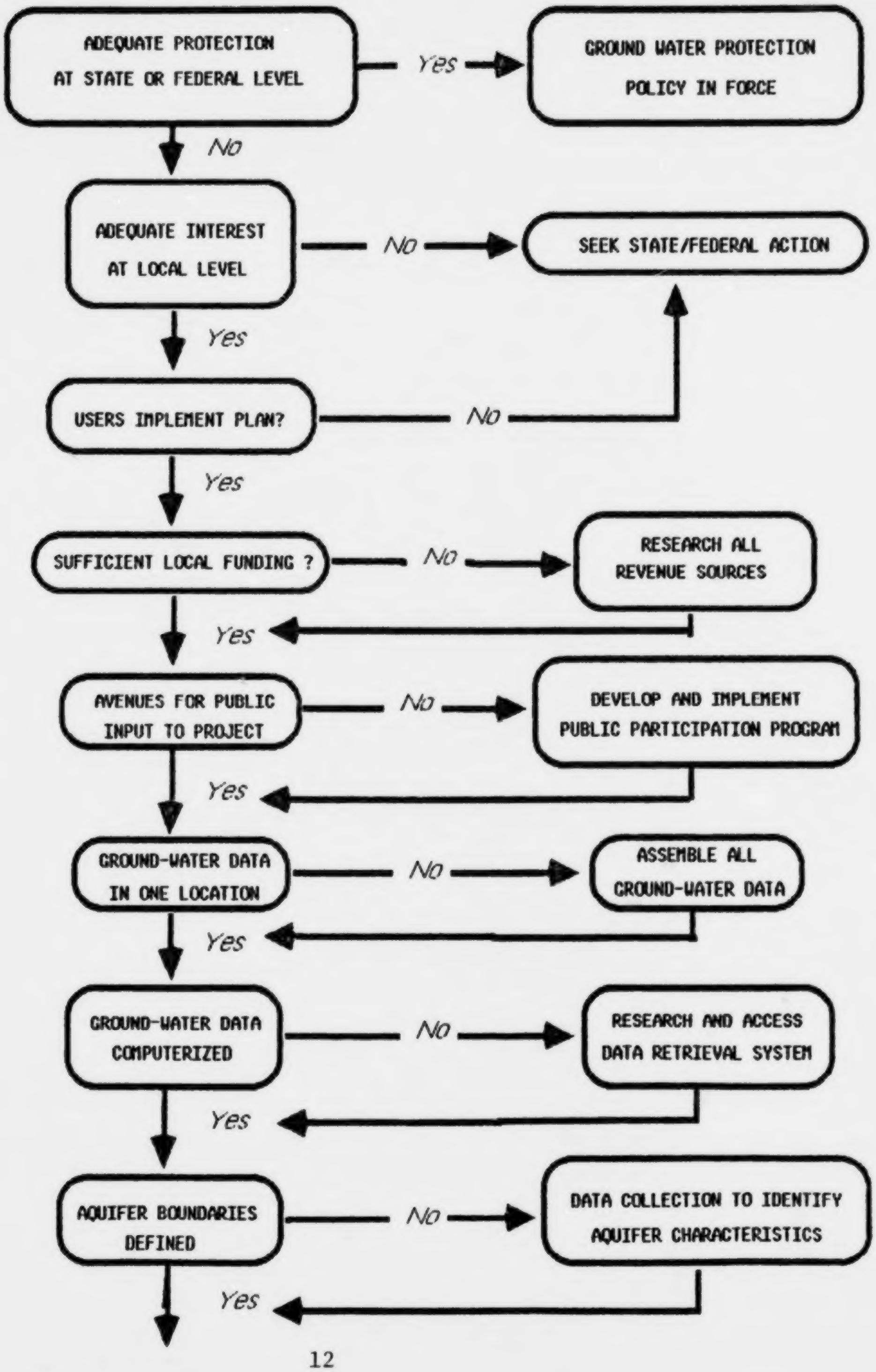
- --A complete description of the aquifer's physical characteristics
- --Withdrawal and recharge rates
- --Present and future use information
- --Suggested zoning actions to ensure appropriate land use decisions to protect the recharge area
- --Appropriate local control of oil and gas activities to mitigate pollution potential
- --Pumping rates and suggested well spacing for municipalities
- --Identification of locations where more development of the aquifer can occur safely and locations where more development should not occur
- --Specifications for appropriate well construction and locations
- --A plan for continued data collection and monitoring of the aquifer

An aquifer development, management and protection plan is an evolving document--it is not meant to be a static blueprint for action, but a point to work from. Through continual data collection on an aquifer, the beneficiaries will be in a position to continually update the plan and improve their management efforts--thus helping to ensure the continued viability of their water resource.

Figure 1

Protocol Flowchart

The chart indicates steps to be taken to insure that local aquifers are fully evaluated and adequately protected for future uses.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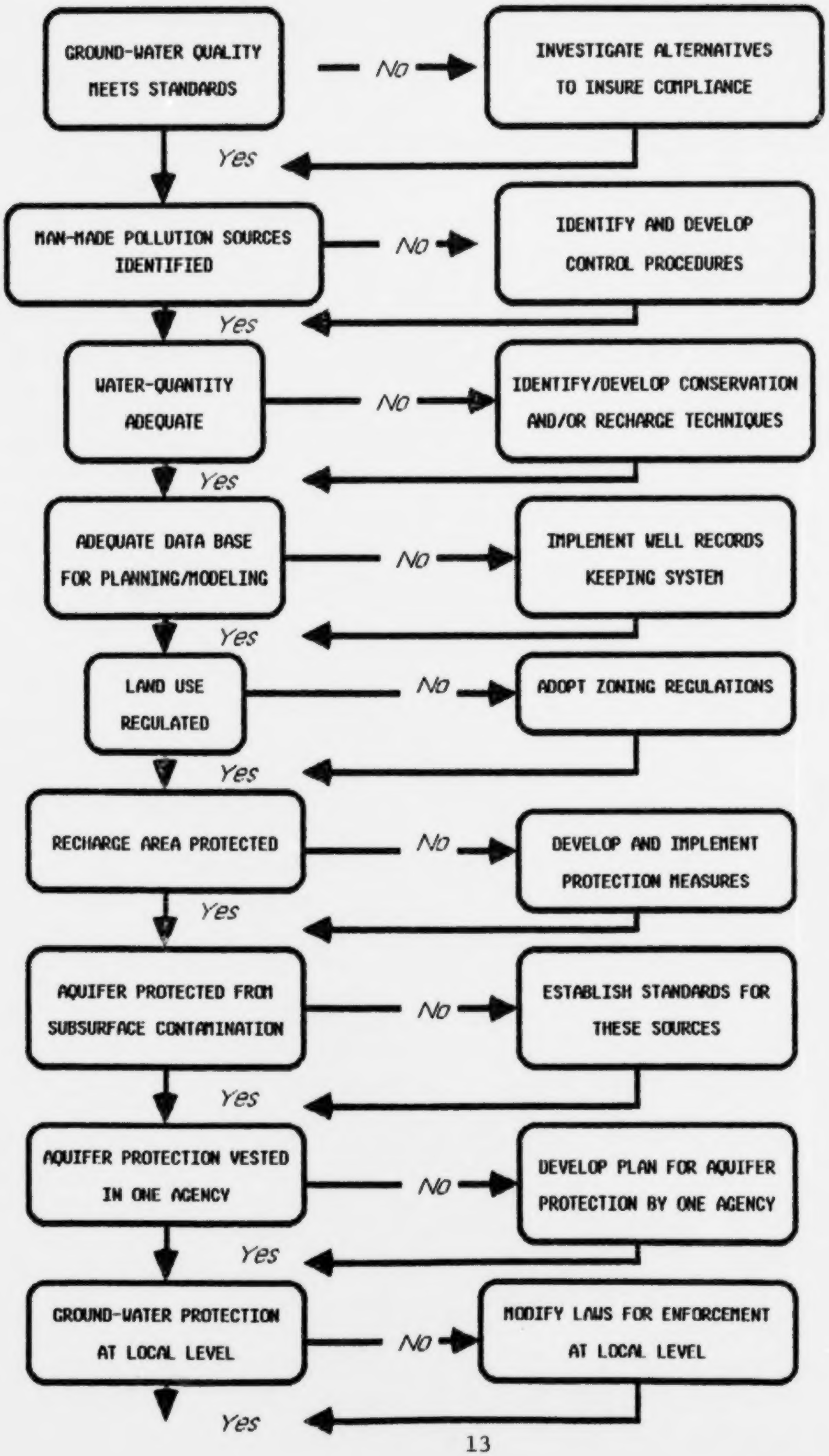
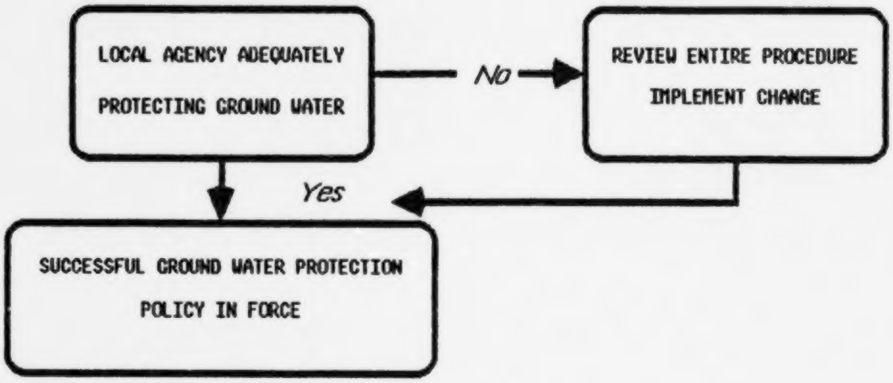
Yes
GROUND WATER PROTECTION POLICY IN FORCE
No
ADEQUATE INTEREST AT LOCAL LEVEL
No
SEEK STATE/FEDERAL ACTION
Yes
USERS IMPLEMENT PLAN?
No
Yes
SUFFICIENT LOCAL FUNDING ?
No
RESEARCH ALL REVENUE SOURCES
Yes
AVENUES FOR PUBLIC INPUT TO PROJECT
No
DEVELOP AND IMPLEMENT PUBLIC PARTICIPATION PROGRAM
Yes
GROUND-WATER DATA IN ONE LOCATION
No
ASSEMBLE ALL GROUND-WATER DATA
Yes
GROUND-WATER DATA COMPUTERIZED
No
RESEARCH AND ACCESS DATA RETRIEVAL SYSTEM
Yes
AQUIFER BOUNDARIES DEFINED
No
DATA COLLECTION TO IDENTIFY AQUIFER CHARACTERISTICS
Yes


GROUND-WATER QUALITY MEETS STANDARDS
No
INVESTIGATE ALTERNATIVES TO INSURE COMPLIANCE
Yes
MAN-MADE POLLUTION SOURCES IDENTIFIED
No
IDENTIFY AND DEVELOP CONTROL PROCEDURES
Yes
WATER-QUANTITY ADEQUATE
No
IDENTIFY/DEVELOP CONSERVATION AND/OR RECHARGE TECHNIQUES
Yes
ADEQUATE DATA BASE FOR PLANNING/MODELING
No
IMPLEMENT WELL RECORDS KEEPING SYSTEM
Yes
LAND USE REGULATED
No
ADOPT ZONING REGULATIONS
Yes
RECHARGE AREA PROTECTED
No
DEVELOP AND IMPLEMENT PROTECTION MEASURES
Yes
AQUIFER PROTECTED FROM SUBSURFACE CONTAMINATION
No
ESTABLISH STANDARDS FOR THESE SOURCES
Yes
AQUIFER PROTECTION VESTED IN ONE AGENCY
No
DEVELOP PLAN FOR AQUIFER PROTECTION BY ONE AGENCY
Yes
GROUND-WATER PROTECTION AT LOCAL LEVEL
No
MODIFY LAWS FOR ENFORCEMENT AT LOCAL LEVEL
Yes


LOCAL AGENCY ADEQUATELY PROTECTING GROUND WATER
No
REVIEW ENTIRE PROCEDURE IMPLEMENT CHANGE
Yes
SUCCESSFUL GROUND WATER PROTECTION POLICY IN FORCE

Appendix I

Resolution Creating the
Garber-Wellington Association

A RESOLUTION
BY THE BOARD OF DIRECTORS OF
THE ASSOCIATION OF CENTRAL OKLAHOMA GOVERNMENTS

WHEREAS, the general purpose local units of government in Central Oklahoma have established under Title 74, O.S. 1971 § 1001 - 1008a, a Council of Governments to enable said public entities to efficiently use their powers by cooperating with each other on a basis of mutual advantage; and,

WHEREAS, Section II(D) of the Agreement Creating the Association of Central Oklahoma Governments provides for the identification and determination of locally perceived issues, problems and priorities requiring concerted coordinated action of a multi-jurisdictional nature; and,

WHEREAS, Section II(H) of the Agreement Creating the Association of Central Oklahoma Governments provides for the ACOG Board of Directors to act on behalf of all or part of the membership to negotiate and consummate contractual agreements of mutual interest to federal, state and local governments; and,

WHEREAS, Section II(I) of the Agreement Creating the Association of Central Oklahoma Governments permits local governmental units to make the most efficient use of their powers by enabling them to cooperate with other localities on a basis of mutual advantage and thereby provide services and facilities in a manner pursuant to forms of governmental organization that will accord best with geographic, economic, population and other factors influencing the needs and development of local communities; and,

WHEREAS, it is the purpose and desire of the undersigned Garber-Wellington Aquifer beneficaries to join in a cooperative effort to perform a study of the Garber-Wellington Aquifer designed in part to determine the boundaries of the fresh water, recharge characteristics of the aquifer, production potential and safe withdrawl zones and rates to identify pollution sources and recommend preventive measures. This study is expected to produce a data base that can be used by local ground water management agencies to better protect and manage the nation's ground water resources.

NOW, THEREFORE, BE IT RESOLVED THAT:

The undersigned members of the Association of Central Oklahoma Governments enter into agreement to carry out the process for a study of the Garber-Wellington Aquifer in Central Oklahoma; and further that it is the intention of said parties to participate with and through the Association of Central Oklahoma Governments (ACOG) as the Council of Governments in this initial effort and in turn the Association of Central Oklahoma Governments shall delegate policy authority to a new policy committee of ACOG as detailed below:

SECTION I

Garber-Wellington Association

(A) There is hereby established an association of Garber-Wellington Aquifer beneficiaries that shall be known hereafter as the Garber-Wellington Association (GWA).

(B) Membership eligibility in the GWA shall consist of all general purpose local units of government within the principal water production/recharge area of the Garber-Wellington Aquifer. Membership in the GWA shall be voluntary.

(C) The governing body of any eligible general purpose local unit of government may attain membership in the GWA by passage of an ordinance, resolution or otherwise pursuant to law by the governing body of the general purpose local unit of government seeking membership and the signing of this resolution signifying concurrence with the objectives of this resolution.

(D) Responsibility for the Garber-Wellington project design, consultant selection, policy direction, plan selection and program development is vested solely with the Garber-Wellington Policy Committee (GWPC), the governing body of the GWA.

(E) Membership eligibility in the Garber-Wellington Policy Committee (GWPC) shall consist of all general purpose local units of government within the ACOG water production/recharge area of the Garber-Wellington Aquifer.

(F) Each individual on the GWPC shall be designated as a Director, and as such shall be entitled to one (1) vote on the GWPC. Each respective governmental member of the GWPC shall select its voting delegate to the GWPC. They shall select not more than two (2) alternate delegates by the same process. Either of the alternate delegates may serve in the absence of the regular selected delegate and have all the voting rights of the regular selected delegate and such delegate shall be a member of the governing board.

Such appointment shall be in writing and specify the power or powers delegated thereto and shall be filed with the GWPC, duly signed by the appointing authority. Provided, however, such alternates shall be elected officials from the appropriate local unit of government.

(G) The GWPC shall meet regularly to perform the following duties:

(1) Initiate, conduct or cause to be conducted studies related to the protection, development and management of fresh water aquifers.

(2) Prepare or cause to be prepared comprehensive plans for the use and protection of ground water aquifers; prepare and adopt plans, policies and programs recommending the governmental and organizational devices or structures necessary for providing proper ground water development in central Oklahoma.

(3) Review recommendations of a Garber-Wellington Technical Committee (GWTC).

(4) Direct establishment of and adopt a budget for the Garber-Wellington Plan of Study; review the overall project annually and make amendments as appropriate.

(H) Officers (chair, vice-chair, secretary) shall be elected by the GWPC from among its members and meetings shall be held on a regular basis. The officers of the GWPC shall be the officers of the GWA. A quorum for the purposes of voting and otherwise conducting the business of the GWPC shall be a simple majority of the designated members. The project staff shall have the primary administrative responsibility to serve the GWPC. Each member entity of the GWPC shall be entitled to a single vote.

SECTION II

Garber-Wellington Technical Committee

Technical guidance of the project shall be vested with the project staff and a Garber-Wellington Technical Committee (GWTC) established to serve the technical needs of the project. The GWTC shall consist of technical and professional local entity staffs. The GWTC shall review the technical aspects of the project and make recommendations to the GWPC.

The Garber-Wellington Technical Committee membership shall consist of an official staff person from each local governmental member entity of the GWA designated by the City Manager or Chief Administrator, (either management or engineering consultants may serve instead of official staff as non-voting members only), the Association Project Director and the EPA Project Director.

The GWTC may, upon approval of the GWPC, appoint other qualified individuals to full voting membership in order to utilize professional expertise and to coordinate the project activities with other related functions.

A chairperson shall be elected by the GWTC and meetings shall be held on a regular basis to review technical procedures and advise the Association Project Director and, in turn, the GWPC. A quorum of the GWTC shall consist of one-fifth of the designated members listed above; however, business conducted in the absence of a quorum shall be forwarded in the same manner as business conducted with a quorum, except that it shall be noted a quorum was not present.

SECTION III

Advisory Commission

There may be established an Advisory Commission whose members shall be appointed by the GWPC and whose duties shall be to serve as a special technical advisory task force to the GWTC. The primary purpose of the Advisory Commission is to provide technical input that will enhance the transferability of the results of this study to other areas of the country that have similar ground water resources and related problems. From time to time, the different agency representatives will be asked to clarify any new state and/or federal rules, regulations and policies affecting the GWPC decision process.

Membership of the Advisory Commission may consist of representatives from each of the national water resources agencies, interested Oklahoma State agencies and interested representatives from agencies of other states and from other entities within the state, but outside the ACOG area. At minimum, the national/state water resources representatives to be requested to serve shall be from the U.S. Geological Survey, Bureau of Reclamation, Environmental Protection Agency, Corps of Engineers, the National Water Well Association and state water resources agencies.

SECTION IV

Work Program

A work program, which contains a multi-year framework for the project, will be developed in accordance with federal requirements. Detailed work activities will be developed each year in an overall program design and adopted by the Garber-Wellington Policy Committee.

SECTION V

Financing

Any local financing of the joint undertaking contemplated by this agreement and effort created thereby shall be based upon the decision of the participating entities of the GWPC.

- - - - - - - - - - - - - - - - - - - -

As a contribution to their continuing efforts to develop and protect the total water resources available to the ACOG area and in conformance with the ACOG Regional Water Plan Years 1985-2000, this resolution is approved through formal adoption by the Board of Directors of the Association of Central Oklahoma Governments and may be executed in multiple counterparts by each participating unit of local government through the ACOG Board representative.

Signature Page

Executive Director

Chairman, ACOG
Board of Directors

J. Deli Gordon
Attorney at Law

December 28, 1978

Appendix II

Forms Used in Computerized Data Base

MASTER FORM #1

```
WELL CONSTRUCTION    (FILE NAME B:CONST)
LEGAL DESCRIP.: T   /R    S.
WELL #:
DATE OF CONSTR.:   / /
DATE OF WORKOVER:   / /
DRILLING METHOD:                (CT,AR,MR,RV,OT)
COMPLETION METHOD:                  (gvl-sl,gvl-sc,cem-pf,slt-cas,screen,ope
SCREEN TYPE:                    (slotted,wr-wrp,louvrd,mil-slt,
                                 tor-slt,pf-gun,pf-jet,pf-unk,unk)
SHOTS/FT:
SCREEN SLOT SIZE:
CASING MATERIAL:                    (steel,pvc,stire)
SCREEN MATERIAL:                    (steel,pvc,stain,stire)
HOLE DIAMETER:   .   IN. FROM       FT.- TO      FT.
HOLE DIAMETER:   .   IN. FROM       FT.- TO      FT.
HOLE DIAMETER:   .   IN. FORM       FT.- TO      FT.
SCREEN/CASING SCHED.:    DIA.   .   IN. FROM       FT.- TO       FT.
SCREEN/CASING SCHED.:    DIA.   .   IN. FROM       FT.- TO       FT.
SCREEN/CASING SCHED.:    DIA.   .   IN. FROM       FT.- TO       FT.
SCREEN/CASING SCHED.:    DIA.   .   IN. FROM       FT.- TO       FT.
TOTAL DEPTH SCREEN OR CASED:      .   FT.
HT. OF TOP OF CASING:   .   FEET ABOVE GROUND SURFACE

SCREENED OR PERFORATED INTERVAL: FROM-TO / FROM-TO / FROM-TO /
     (0 - 99 FT.) :
   (100 - 199 FT.) :
   (200 - 299 FT.) :
   (300 - 399 FT.) :
   (400 - 499 FT.) :
   (500 - 599 FT.) :
   (600 - 699 FT.) :
   (700 - 799 FT.) :
   (800 - 899 FT.) :
   (900 - 999 FT.) :
 (1000 - 1299 FT.) :

GROSS INTERVAL SCREEN/CASE-TOTAL FOOTAGE:      .   FEET
AGGREGATE TOTAL OF SCREEN/PERFORATED SANDS:      .   FEET
SANITARY SEAL TYPE:            (CEMNT,CLAY,CL/CA,NONE)
                   FROM     .  FT.- TO     .  FT. BELOW GROUND SURFACE
OTHER SEALS:              (CEMNT,CLAY,CL/CA,NONE)
               FROM     .  FT.-TO     .  FT. BELOW GROUND SURFACE
               FROM     .  FT.-TO     .  FT. BELOW GROUND SURFACE
```

MASTER FORM #2

LEGAL DESCRIP.: T /R S.
WELL #:
REPORTED ORIG.STATIC LEVEL: . FEET
DATE: / /
MOST RECENT STATIC LEVEL: . FEET
DATE: / /
MEAS.POINT HT.: . HT. ABOVE GROUND SURFACE
MEAS.POINT ELEV.: . FEET
WTR LEV.: DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT
DATE - - /WL . FT /W EL. . FT /METHOD /STAT

METHOD OF MEASUREMENT: AIR.,EST.,PR/GA,CA/GA,REPRT,ST/TP,EL/TP
SITE STATUS: PUM,RP,NP,NRP

MASTER FORM #3

LEGAL DESCRIP.: T /R S.
WELL #:
DATE WELL PLACED IN SERVICE: / /
ANNUAL PUMPING RATE: . IN ACRE FEET/YEAR
INLINE RATE OR VOLUME METER: (YES,NO)
PUMP CAPACITY: GPM
REPORTED YEILD: . GPM

REPORTED USE: YEAR	USE	METHOD MEASUR.	PMPING LEVEL
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	
19 /	MILLION GAL.PER DAY /	/	

METHOD OF MEASUREMENT: WIER,VOL.MT,ORIFIC,VOLUMT
PUMPING LEVELS ARE FROM MEASURING POINT

MASTER FORM #4

LEGAL DESCRIP.: T /R S.
WELL #:
TOP OF FRESH WATER DEPTH: . FEET BELOW LAND SURFACE
ELEVATION: . FEET
BOTOM OF FRESH WATER DEPTH: . FEET BELOW LAND SURFACE
ELEVATION: . FEET
TOP OF SALT WATER DEPTH: . FEET BELOW LAND SURFACE
ELEVATION: . FEET
TOP OF BRACKISH WATER DEPTH: . FEET BELOW LAND SURFACE
ELEVATION: . FEET
BOTTOM OF SULFATE WATER DEPTH: . FEET BELOW LAND SURFACE
ELEVATION: . FEET
GROSS AQUIFER THICKNESS OF FRESH WATER: . FEET
AGGREGATE THICKNESS OF FRESH WATER: . FEET
SAND SHALE RATIO: . / .

MASTER FORM #5

```
LEGAL DESCRIP.: T   /R    S.
WELL#:
FORMATION TAPPED:          (PGW,PH,QAL,QT)
TOP OF FORMATION DEPTH:      .   FEET BELOW GROUND SURFACE
             ELEVATION:      .   FEET
BOTTOM OF FORMATION DEPTH:      .   FEET BELOW GROUND SURFACE
                ELEVATION:      .   FEET
****************
FORMATION TAPPED:          (PGW,PH,QAL,QT)
TOP OF FORMATION DEPTH:      .   FEET BELOW GROUND SURFACE
             ELEVATION:      .   FEET
BOTTOM OF FORMATION DEPTH:      .   FEET BELOW GROUND SURFACE
                ELEVATION:      .   FEET
****************
FORMATION TAPPED:          (PGW,PH,QAL,QT)
TOP OF FORMATION DEPTH:      .   FEET BELOW GROUND SURFACE
             ELEVATION:      .   FEET
BOTTOM OF FORMATION DEPTH:      .   FEET BELOW GROUND SURFACE
                ELEVATION:      .   FEET
```

MASTER FORM #6

LEGAL DESCRIP.: T /R S.
WELL #:
COMMENTS:

MASTER FORM #7

LEGAL DESCRIP.: T /R S.
WELL #:
PUMP HORSE POWER: . HP
RATED CAPACITY: . GPM
PUMP TYPE: (SUBM.,TURB.,CENTR,JET,OTHER)
PUMP INTAKE SETTING: . FEET
OTHER INFORMATION: (YES,NO)

MASTER FORM #8

```
LEGAL DESCRIP.: T   /R    S.
WELL #:
DATE OF ANALYSES:   /  /
SOURCE:
LENGTH OF TIME IN SERVICE PRIOR TO SAMPLING:      YEARS
LENGTH OF TIME PUMPED PRIOR TO SAMPLING:     .   HOURS AT      GPM
ANALYSES:                 DATA   , UNITS (ppm,mg/l,grains,u/l)
         pH             :   .
         CONDUCTANCE    :
         TDS            :      .  ,
         TOTAL HARDNESS:      .  ,
         CALC. HARDNESS:      .  ,
         ALKALINITY     :     .  ,
         CHLORIDES      :     .  ,
         IRON           :     .  ,
         SULFATES       :     .  ,
         MANGANESE      :     .  ,
         CHROMIUM       :     .  ,
         SELENIUM       :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
******************
DATE OF ANALYSES:   /  /
SOURCE:
LENGTH OF TIME IN SERVICE PRIOR TO SAMPLING:      YEARS
LENGTH OF TIME PUMPED PRIOR TO SAMPLING:     .   HOURS AT      GPM
ANALYSES:                 DATA   , UNITS  (ppm,mg/l,grains,u/l)
         pH             :   .
         CONDUCTANCE    :
         TDS            :      .  ,
         TOTAL HARDNESS:      .  ,
         CALC. HARDNESS:      .  ,
         ALKALINITY     :     .  ,
         CHLORIDES      :     .  ,
         IRON           :     .  ,
         SULFATES       :     .  ,
         MANGANESE      :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
******************
DATE OF ANALYSES:   /  /
SOURCE:
LENGTH OF TIME IN SERVICE PRIOR TO SAMPLING:      YEARS
LENGTH OF TIME PUMPED PRIOR TO SAMPLING:     .   HOURS AT      GPM
ANALYSES:                 DATA   , UNITS   (ppm,mg/l,grains,u/l)
         pH             :   .
         CONDUCTANCE    :
         TDS            :      .  ,
         TOTAL HARDNESS:      .  ,
         CALC. HARDNESS:      .  ,
         ALKALINITY     :     .  ,
         CHLORIDES      :     .  ,
         IRON           :     .  ,
         SULFATES       :     .  ,
         MANGANESE      :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
******************
DATE OF ANALYSES:   /  /
SOURCE:
LENGTH OF TIME IN SERVICE PRIOR TO SAMPLING:      YEARS
LENGTH OF TIME PUMPED PRIOR TO SAMPLING:     .   HOURS AT      GPM
ANALYSES:                 DATA     UNITS     (ppm,mg/l,grains,u/l)
         pH             :   .
         CONDUCTANCE    :
         TDS            :      .  ,
         TOTAL HARDNESS:      .  ,
         CALC. HARDNESS:      .  ,
         ALKALINITY     :     .  ,
         CHLORIDES      :     .  ,
         IRON           :     .  ,
         SULFATES       :     .  ,
         MANGANESE      :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
                        :     .  ,
```

MASTER FORM #9

LEGAL DESCRIP.: T /R S.
WELL #:
LAT./LONG.: . / .
deg min sec deg min sec
OWNER:
TYPE OF WELL: (PROD.,T.H.,MONT.,OBS.,ABAN.)
FORMAT.TAPPED: (Pgw,Ph,Qal,Qt)
ELEVATION: . FEET
CURRENT USE: (A,D,I,In,Is,M,O&G,OBS,P,S,TH)
DEPTH: . FEET
WELL LOG: / (DRILL,GEOLO)
ELEC.LOG: / / / / (S.PT.,REST,NORM,CAL.,GAMM,NEUT)

WELL CONSTRUC.: (Y-yes;N-no;1,2,3 number of entries)
PUMP INFO.:
PUMP TEST:
ANNUAL USE:
WATER LEVELS:
WATER QUALITY:
AQUIFER DATA:
GARBER W.Q.:
COMMENTS:

ENTITY: / / / / (EEI,MUNC,OSDH,OWRB,USGS)
ACCURACY:

MASTER FORM #10

```
PUMP TEST INFORMATION (FILE NAME B:PUMPT)
LEGAL DESCRIP.: T   /R     S.
WELL #:
ORIGINAL PUMP TEST DATE:    /  /
TYPE OF TEST:           (SP.CP.,CT.RT.,ST.DW.)
**************************************************
PUMPING RATE AT BEGINNING OF TEST:         GPM   *
PUMPING RATE AT END OF TEST:        GPM          *
LENGTH OF TEST:         HOURS                    *
DRAWDOWN:        FEET                            *
**************************************************
METHOD OF MEASUREMENT:         (METER,BAILER,ORIFI.,WIER)
Q/S AT END OF TEST:     .  GPM PER FOOT OF DRAWDOWN
Q/S AFTER 24 HOURS:     .  GPM PER FOOT OF DRAWDOWN
TRANSMISSIVITY:     .   GAL./DAY/SQ.FT.
PERMEABILITY:     .   GAL./DAY/CU.FT.
STORAGE COEFFICIENT:  .   *10-
USE OF WELL BETWEEN TESTS:
WHO CALCULATED THE DATA ABOVE:
IS RAW DATA AVAILABLE:
22222222222222222222222222222222222
PUMP TEST DATE:   /  /
TYPE OF TEST:           (SP.CP.,CT.RT.,ST.DW.)
**************************************************
PUMPING RATE AT BEGINNING OF TEST:         GPM   *
PUMPING RATE AT END OF TEST:        GPM          *
LENGTH OF TEST:         HOURS                    *
DRAWDOWN:        FEET                            *
**************************************************
METHOD OF MEASUREMENT:         (METER,BAILER,ORIFI.,WIER)
Q/S AT END OF TEST:     .  GPM PER FOOT OF DRAWDOWN
Q/S AFTER 24 HOURS:     .  GPM PER FOOT OF DRAWDOWN
TRANSMISSIVITY:     .   GAL./DAY/SQ.FT.
PERMEABILITY:     .   GAL./DAY/CU.FT.
STORAGE COEFFICIENT:  .   *10-
USE OF WELL BETWEEN TESTS:
WHO CALCULATED THE DATA ABOVE:
IS RAW DATA AVAILABLE:
33333333333333333333333333333333333
PUMP TEST DATE:   /  /
TYPE OF TEST:           (SP.CP.,CT.RT.,ST.DW.)
**************************************************
PUMPING RATE AT BEGINNING OF TEST:         GPM   *
PUMPING RATE AT END OF TEST:        GPM          *
LENGTH OF TEST:         HOURS                    *
DRAWDOWN:        FEET                            *
**************************************************
METHOD OF MEASUREMENT:         (METER,BAILER,ORIFI.,WIER)
Q/S AT END OF TEST:     .  GPM PER FOOT OF DRAWDOWN
Q/S AFTER 24 HOURS:     .  GPM PER FOOT OF DRAWDOWN
TRANSMISSIVITY:     .   GAL./DAY/SQ.FT.
PERMEABILITY:     .   GAL./DAY/CU.FT.
STORAGE COEFFICIENT:  .   *10-
USE OF WELL BETWEEN TESTS:
WHO CALCULATED THE DATA ABOVE:
IS RAW DATA AVAILABLE:
44444444444444444444444444444444444
PUMP TEST DATE:   /  /
TYPE OF TEST:           (SP.CP.,CT.RT.,ST.DW.)
**************************************************
PUMPING RATE AT BEGINNING OF TEST:         GPM   *
PUMPING RATE AT END OF TEST:        GPM          *
LENGTH OF TEST:         HOURS                    *
DRAWDOWN:        FEET                            *
**************************************************
METHOD OF MEASUREMENT:         (METER,BAILER,ORIFI.,WIER)
Q/S AT END OF TEST:     .  GPM PER FOOT OF DRAWDOWN
Q/S AFTER 24 HOURS:     .  GPM PER FOOT OF DRAWDOWN
TRANSMISSIVITY:     .   GAL./DAY/SQ.FT.
PERMEABILITY:     .   GAL./DAY/CU.FT.
STORAGE COEFFICIENT:  .   *10-
USE OF WELL BETWEEN TESTS:
WHO CALCULATED THE DATA ABOVE:
IS RAW DATA AVAILABLE:
```

Appendix III

Municipal Well Records Keeping System

WELL FIELD MONITORING

Objectives:

Just as with a surface water lake, the ground-water reservoir must be managed. To have a continuing supply, the amount of water pumped from the reservoir must be controlled to match the amount of recharge or inflow.

Good management of a ground-water reservoir is difficult. It requires (1) an accurate historical account of all water removed by pumping, natural outflow and other losses, (2) accurate measurements of the historical recharge or inflow into the reservoir, and (3) control of water removed to balance inflow.

In addition to providing the necessary data required for the proper and efficient maintenance of the well field, this data will provide invaluable engineering data. This data can then be used when future expansion to the existing well field are made and will help to insure a safe and efficient design of any future expansion to the well field.

An effective monitoring program should include the following monitoring functions.

1. Monitoring of the well and well house operation.
2. Monitoring of the water levels.
3. Monitoring of pumps.
4. Monitoring of the water quality.

The monitoring of the water levels and water quality needs to be done not only on the production wells, but also on the monitoring wells, and abandoned production wells.

Monitoring Program

Monitoring of Water Levels

Data on water levels should be collected in three different groupings as follows:

1. Monthly measurements taken with the pump on.
2. Bi-yearly measurements of each production well.
3. Bi-yearly measurements of the monitoring wells.

Monthly Measurements:

Once each month the following measurements should be made of each well:

1. Water meter reading
2. Power meter reading
3. Depth to water
4. Water pressure
5. Pumping rates

    a. City name.
    b. Well number.
    c. Well location.
    d. Date of sampling.

6. Obtain samples.

7. Place the sample in a cooler containing ice (ACOG will provide the cooler).

8. Deliver sample to Greg Wallace with ACOG as soon as possible.

When the analyses are completed the results will be forwarded on to the City. The first round of samples should be taken by October 1, 1980.

These measurements will monitor the performance of both the well and the pump. If any sudden change is noted in these data, the cause of the change should be identified. Forms for recording this data are given. After collection of this data the following information should be calculated:

1. Elevation of the water table.
2. Total head.
3. Total volume of water pumped since the last measurement.
4. Adjusted volume of water pumped (volume meter corrected for its inaccuracies).
5. The power consumed since the last measurement.
6. The average power consumed since the last measurement.

Forms for the calculation and recording of these data are provided.

Bi-Yearly Measurement of Each Production Well:

Twice each year each of the Production Wells should remain out of operation for approximately two weeks. After this period of time the depth to water should then be measured. Forms for recording these measurements are provided.

Bi-Yearly Measurements to be Taken at Monitoring Well:

Twice each year the depth of water should be measured in each of the monitoring and observation wells. In addition to recording the depth to water in each well, a listing of all the production wells on at the time of the measurements should be made. Forms for these data are also included.

Monitoring of Pump Performance

Once each year Pump Performance curves should be run of each pump.

Procedure:

- I. Before starting the tests the well being tested should have been on for at least 8 hours.
- II. Close prelube water ,line valve.
- III. Record the following measurements on the forms provided.
  - A. Pumping Rate
    1. Using rate meter
    2. Using volume meter
  - B. Depth to water
  - C. Line pressure
  - D. Rate of power consumption (determined by timing the length of time required for the power usage disk (located in the power meter) to make 1 revolution.

IV. Attach an orifice weir

V. Open the pressure relief valve to bypass line.

VI. Close the valve to the main waterline. Caution: Do not exceed a line pressure of 200 psi.

VII. Install an accurate pressure gauge on the water tap (gauge should be accurate to 1 psi).

VIII. Adjust pressure relief valve such that the line pressure is at 80 psi and wait 10 minutes before proceeding.

IX. Record the following data

- A. Pumping rate.
    1. Using rate meter.
    2. Using volume meter.
    3. Using orifice wier.
- B. Depth to water.
- C. Line pressure using both pressure gauges.
- D. Rate of power consumption.

X. Increase the pressure by 20 psi, wait 10 minutes.

XI. Repeat steps IX and X until measurements have been made at a line pressure of 180 psi.

XII. Set pressure relief valve at 140 spi.

XIII. Return the system to a normal operating condition.

Calculations:

After completion of the test, calculate the following data:

1. Total head. Calculate according to the following equation:

$$H_T = H_L \times 2.31 + DTW + 18$$

where

H_T is the total head

H_L is the line pressure

and

DTW is the depth to water

2. Calculate the pump efficiency by using the following equation:

$$E = \frac{H_T \times P \times Q}{191 \times Kh}$$

where

P is the rate of power consumption

Kh is the meter constant

and

Q is the pumping rate determined using the orifice weir.

After all of this data has been collected, the data should then be placed on the forms provided.

Overall Pump Efficiencies

The overall efficiency of a well can be determined by using the following equation:

$$E = \frac{V \times H_T}{318{,}200 \times kw}$$

where

V is the volume pumped

H_T is the total head (in feet of water), and includes both the pumping lift and discharge heads.

K is the number of kilowatts consumed (read from the power meter).

GW-XS

MAIL FORM WITH SAMPLE TO:
OKLAHOMA STATE DEPT. OF HEALTH
WATER QUALITY LABORATORY
N.E. 10th & STONEWALL
OKLAHOMA CITY, OKLA. 73105

RETURN TO: NAME Greg Wallace, Project Engineer
ACOG
ADDRESS 4801 Classen Blvd.
CITY/STATE Oklahoma City, OK 73118
ZIP

OKLAHOMA STATE DEPARTMENT OF HEALTH
WATER QUALITY MONITORING AND RESEARCH DIVISION
ANALYSIS REQUEST AND WORK SHEET

FILL IN BOXES 1, 2, 3 AND 4 COMPLETELY

1. LEGAL DESCRIPTION

City
County
Ground
Surface
/4 /4 /4 Sec. T N S R E W

2. SAMPLE ORIGIN

Well Depth
Stream
Other

LAB. USE ONLY

Sample No.
Received
Completed
Basin No.
Discharge
CODE

3. SAMPLE DESCRIPTION

Type Water
Source Well
Date Collected

4. REQUEST

Analysis Request Specific conductivity, pH, Total Hardness, sulfate, chlorides
Purpose ACOG's Municipal Water Quality Base Study

PARAMETERS	MG/L
[✓ Total Hardness]	
Calcium Hardness	
Total Alkalinity	
"P" Alkalinity	
[✓ Chloride]	
Dissolved Solids	
[✓ pH]	
[✓ Sulfate]	
Nitrate-N	
Iron	
Manganese	
Fluoride	
Turbidity	
BOD	
COD	
Sett. Solids	
Susp. Solids	
Total Solids	
Boron	
Phenol	
Cyanide	
TOC	
Color	
Nitrite-N	
Ammonia-N	
Organic N-N	
Total PO_4-P	
Ortho. PO_4-P	
Specific Cond.	
Oil & Grease	

FIELD PARAMETERS

D.O.		[✓ pH]	
Temp.		[✓ Sp.Co.]	

METALS/PESTICIDES	MG/L
Na	
K	
Ca	
Mg	
Fe	
Mn	
Ag	
Cd	
Cr	
Cu	
Pb	
Zn	
Ba	
As	
Se	
Hg	

COMMENTS

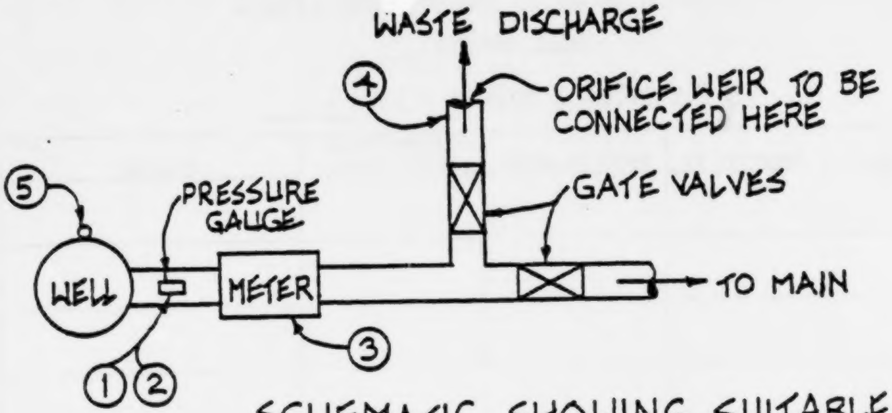
DIAGRAM I

Engineering Enterprises, Inc. 1225 West Main - Suite 215 Norman, Oklahoma 73069 (405) 329-8300

PROJECT ACOG PROJECT NUMBER

SUBJECT NECESSARY FACILITIES FOR COMPLETE WELL MONITORING PROGRAM BY MT DATE 6-17-80

PAGE 3 OF 4


WASTE DISCHARGE
④
ORIFICE WEIR TO BE CONNECTED HERE
⑤
PRESSURE GAUGE
GATE VALVES
WELL
METER
TO MAIN
①②
③

SCHEMATIC SHOWING SUITABLE FACILITIES FOR RUNNING A PUMP TEST

ITEMS NECESSARY FOR PUMP TEST

1. TAPPED HOLE FOR PRESSURE GAUGE
2. TAPPED HOLE FOR WATER SAMPLING
3. FLOW METER
4. METHOD FOR DISCHARGE OF FULL PUMPING CAPACITY TO WASTE THROUGH ORIFICE.
5. ACCESS FOR AIR LINE OR SOUNDER TO MEASURE WATER LEVEL INSIDE CASING.

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

CITY ________________

WELL FIELD MONITORING
MONITORING WELLS STATIC WATER LEVELS

WELL NUMBER ___

ELEVATION OF MARKER POINT _____

Date	**Recorded By**	**Depth to Water**	**Evaluation of Water Table**	**Remarks**

ACOG MUNICIPAL WELL RECORDS

CITY ________________

Bi-Yearly Measurement of the Static Water Levels

Well #	Date	Date the Well Was Last Pumped	Depth to Water	Production Wells on at the Time of the Measurement

* To be made after the pump has been off for at least two weeks)

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

CITY ____________

WELL FIELD MONITORING
DATA SHEET

WELL NUMBER ___

DATE	RECORDED BY	WATER METER READING	POWER METER READING	PUMP		DEPTH TO WATER		WATER LINE PRESSURE	PUMPING RATE	REMARKS
				ON	OFF	GAGE	FEET			

Electric Meter Serial # ____________

Electric Meter Constant ____________

SERVICE WORK ON WELL

DATE	TYPE OF WORK PERFORMED	REMARKS

ACOG MUNICIPAL WELL RECORDS

CITY ________________

WELL FIELD MONITORING CALCULATION SHEET

WELL NUMBER ___

DATE	RECORDED BY	ELEVATION OF WATER TABLE	TOTAL HEAD*	VOLUME OF WATER PUMPED	ADJUSTED VOLUME OF WATER PUMPED **	POWER CONSUMED	POWER CONSUMED /1000 GAL.	REMARKS

* Includes 18 ft. of head loss in pump and 5 ft. of head loss between pump and pressure gage.

**The factor to adjust volume meter to orifice meter is _____, determined from pump curve.

Elevation of Pump House Floor ______________.

Elevation of Drawdown Tube ________________.

Depth of the bottom of the drawdown tube ________________.

Original Static Water Table Elevation ________________,

Depth ________________.

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

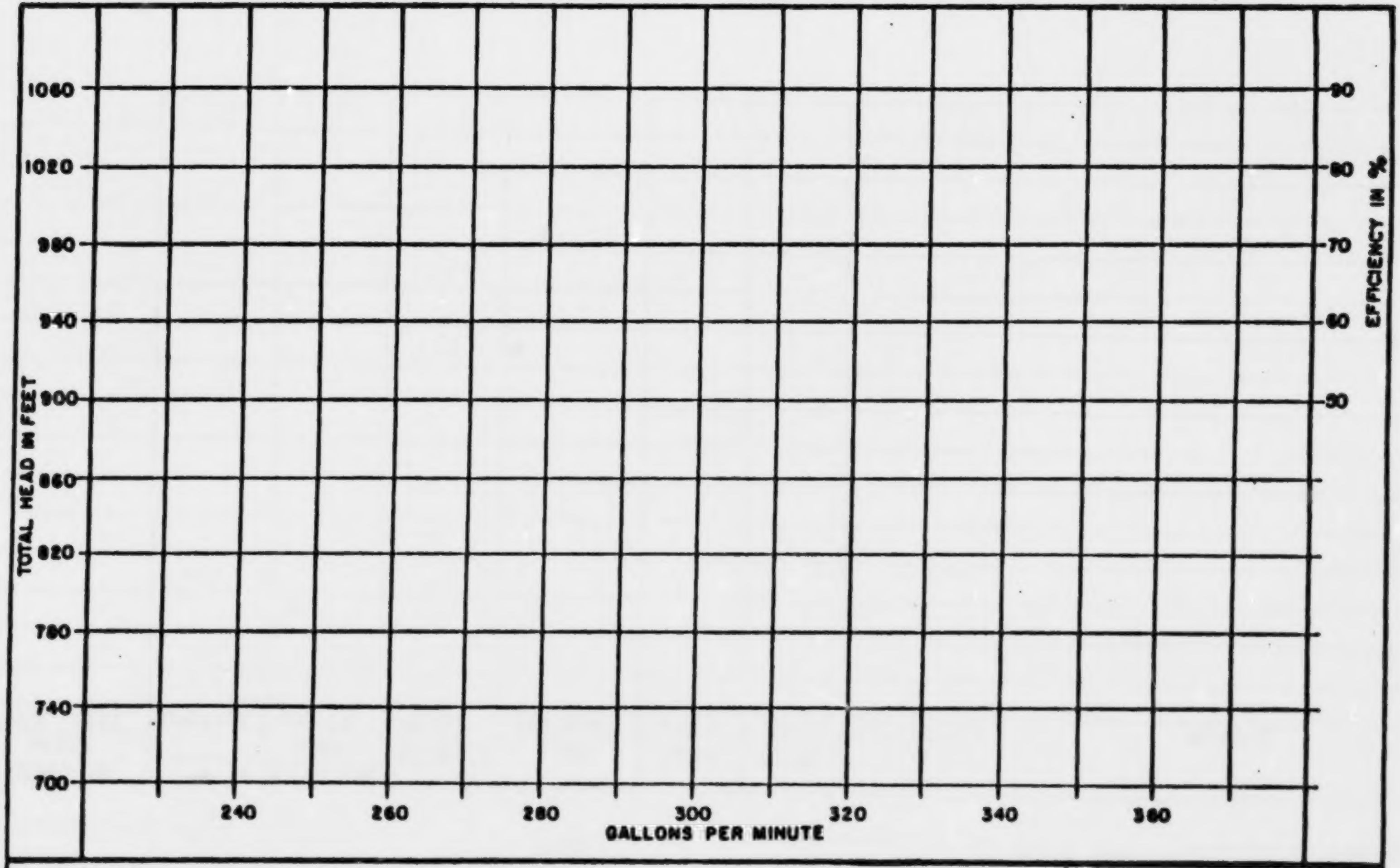
CITY ____________

WELL FIELD MONITORING
PUMP TEST DATA

WELL # ____________________ DATE ____________________ METER CONSTANT ____________________

TIME	DEPTH TO WATER	PUMPING RATE			LINE PRESSURE	POWER USAGE	TOTAL HEAD	% EFFICIENCY	REMARKS
	GAGE FEET	ORIFICE	RATE METER	VOLUME METER					

NOTES:



CITY OF
DATE: ____ Day ____ Mo. ____ Yr.
WELL NO.

A C O G

MUNICIPAL RECORDS

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

CITY ____________

WELL FIELD MONITORING
PUMP TEST DATA

WELL #______________________ DATE________________________ METER CONSTANT_________________

TIME	DEPTH TO WATER		PUMPING RATE			LINE PRESSURE	POWER USAGE	TOTAL HEAD	% EFFICIENCY	REMARKS
	GAGE	FEET	ORIFICE	RATE METER	VOLUME METER					

NOTES:

EXAMPLES

ACOG MUNICIPAL WELL RECORDS

CITY Yukon

WELL FIELD MONITORING
MONITORING WELLS STATIC WATER LEVELS

WELL NUMBER Y-II-982

ELEVATION OF MARKER POINT 12

Date	Recorded By	Depth to Water	Evaluation of Water Table	Remarks
8-23-77	JH	369		
8-25-77	JH	372		
2-16-78	RLJ	373.04		
9-14-78	KC	371		
1-25-79	WTA	386.10		

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

CITY Nowhere

Bi-Yearly Measurement of the Static Water Levels

Well #	Date	Date the Well Was Last Pumped	Depth to Water	Production Wells on at the Time of the Measurement
1	9-15-82	9-1-82	482.93	3,4.5,7,8,10
2	9-15-82	8-30-82	495.79	3,4,5,7,8,10
3	10-1-82	9-15-82	498.58	1,2,6,9
4	10-1-82	9-15-82	550.48	1.2,6,9
5	11-1-82	10-10-82	470.32	1,3,7.8
6	9-15-82	9-1-82	481.39	3,4.5,7,8,10
7	11-1-82	10-13-82	479.26	1,3,7.8
8	11-1-82	10-15-82	471.05	1,3,7.8
9	9-15-82	9-1-82	500.01	3,4,5,7,8,10
10	10-1-82	9-14-82	455.02	1,2,6.9

* To be made after the pump has been off for at least two weeks.

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

CITY Yukon

WELL FIELD MONITORING
DATA SHEET

WELL NUMBER 8

DATE	RECORDED BY	WATER METER READING	POWER METER READING	PUMP		DEPTH TO WATER		WATER LINE PRESSURE	PUMPING RATE	REMARKS
				ON	OFF	GAGE	FEET			
6·24·78	BB	0	0		✓		302.05	0	0	
9·19·78	KB	8197	8054	✓			480.35	96	380	
10·18·78	KB	111837	46500	✓			502.65	107	370	
3·26·79	NTA	768954	(2) 80249	✓			566.33	100	360	
6·19·79	NTA	(1) 72081	(4) 2202	✓			517.11	110	350	

Electric Meter Serial # 46943155

Electric Meter Constant 43.2

SERVICE WORK ON WELL

DATE	TYPE OF WORK PERFORMED	REMARKS

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

CITY YUKON

WELL FIELD MONITORING CALCULATION SHEET

WELL NUMBER 8

DATE	RECORDED BY	ELEVATION OF WATER TABLE	TOTAL HEAD*	VOLUME OF WATER PUMPED	ADJUSTED VOLUME OF WATER PUMPED **	POWER CONSUMED	POWER CONSUMED /1000 GAL.	REMARKS
6.24.78	BB	957.36		0	0	0		
9.19.78	KB	779.05		819700	770518	8054	10.5	
10.18.78	KB	756.76		10364000	9742160	38446	3.9	
3.26.79	WTA	693.08		65711100	617684	233749	3.8	
6.19.79	WTA	742.30		30312700	28493939	121953	4.3	59.0% overall eff. since
								6.24.78

* Includes 18 ft. of head loss in pump and 5 ft. of head loss between pump and pressure gage.

**The factor to adjust volume meter to orifice meter is .94, determined from pump curve.

Elevation of Pump House Floor 1257.41.

Elevation of Drawdown Tube 1259.41.

Depth of the bottom of the drawdown tube 726.

Original Static Water Table Elevation 302.05.

Depth 778 ft..

ACOG MUNICIPAL WELL RECORDS

CITY Yukon

WELL FIELD MONITORING
PUMP TEST DATA

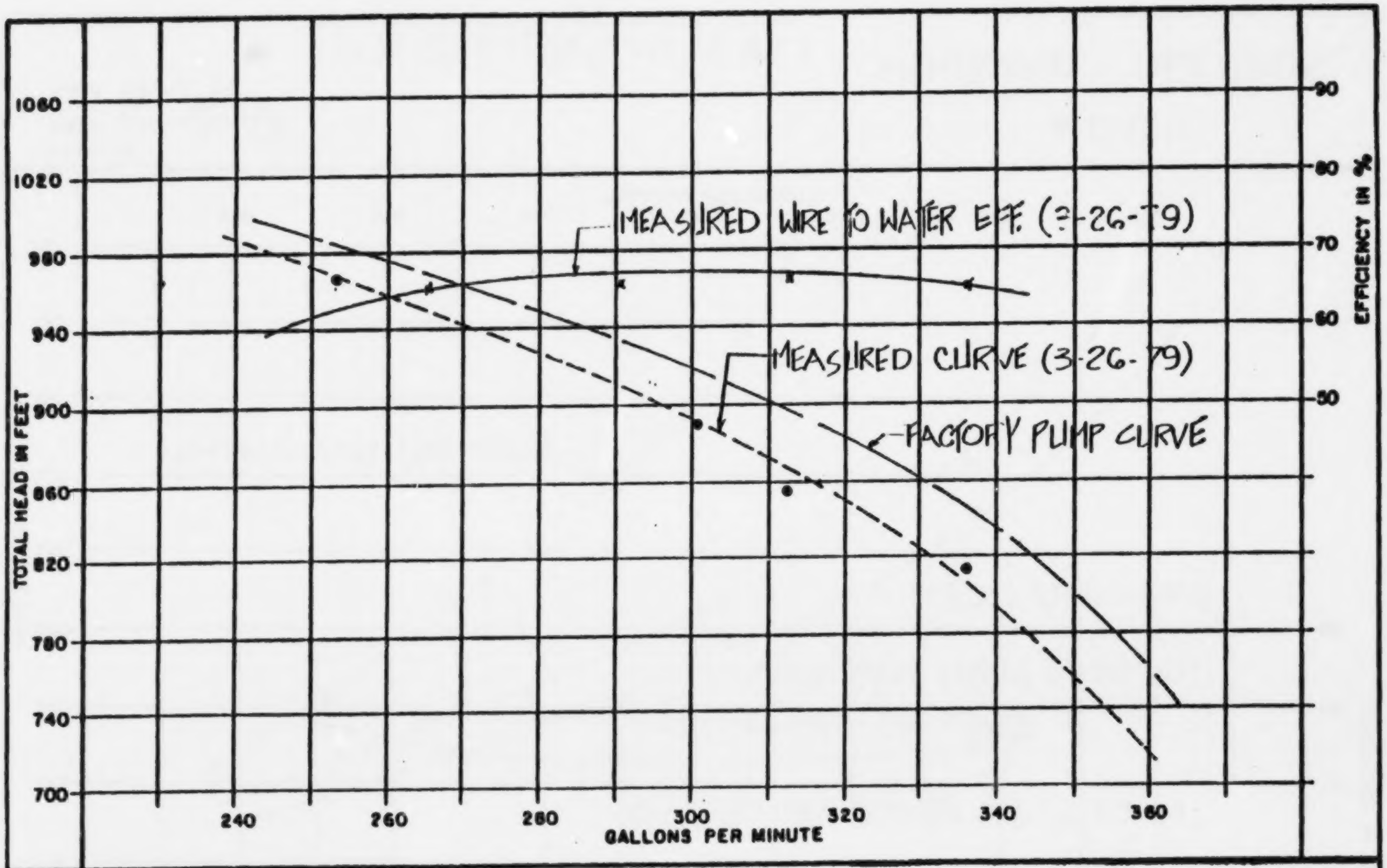
WELL # Y-8

DATE 3 · 26 · 79

METER CONSTANT 43.2

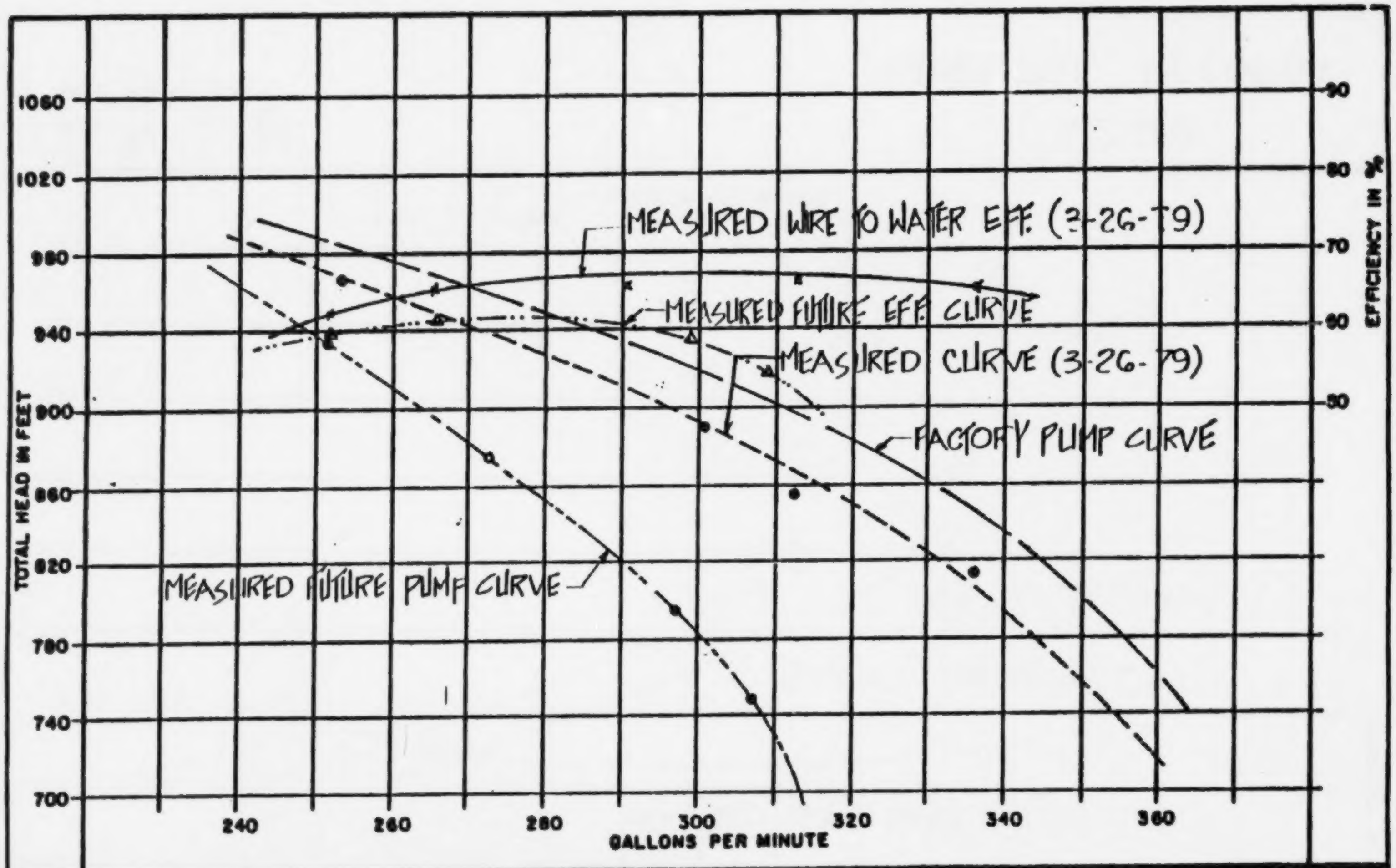
TIME	DEPTH TO WATER	PUMPING RATE			LINE PRESSURE	POWER USAGE	TOTAL HEAD	% EFFICIENCY	REMARKS
	GAGE FEET	ORIFICE	RATE METER	VOLUME METER					
10:00	391.10	0	0	0	0	0	0	0	
10:15	566.30	336	350	360	100	1.96	815.3	65.1	
10:25	559.37	313	330	335	120	1.99	854.6	64.5	
10:35	549.00	301	310	315	140	2.02	890.4	65.6	
10:42	544.40	265	285	290	165	2.08	955.0	63.7	
10:48	532.90	254	260	265	180	2.13	966.7	63.4	

NOTES:



CITY OF
DATE: 26 Day 3 Mo. 79 Yr.
WELL NO. Y-8

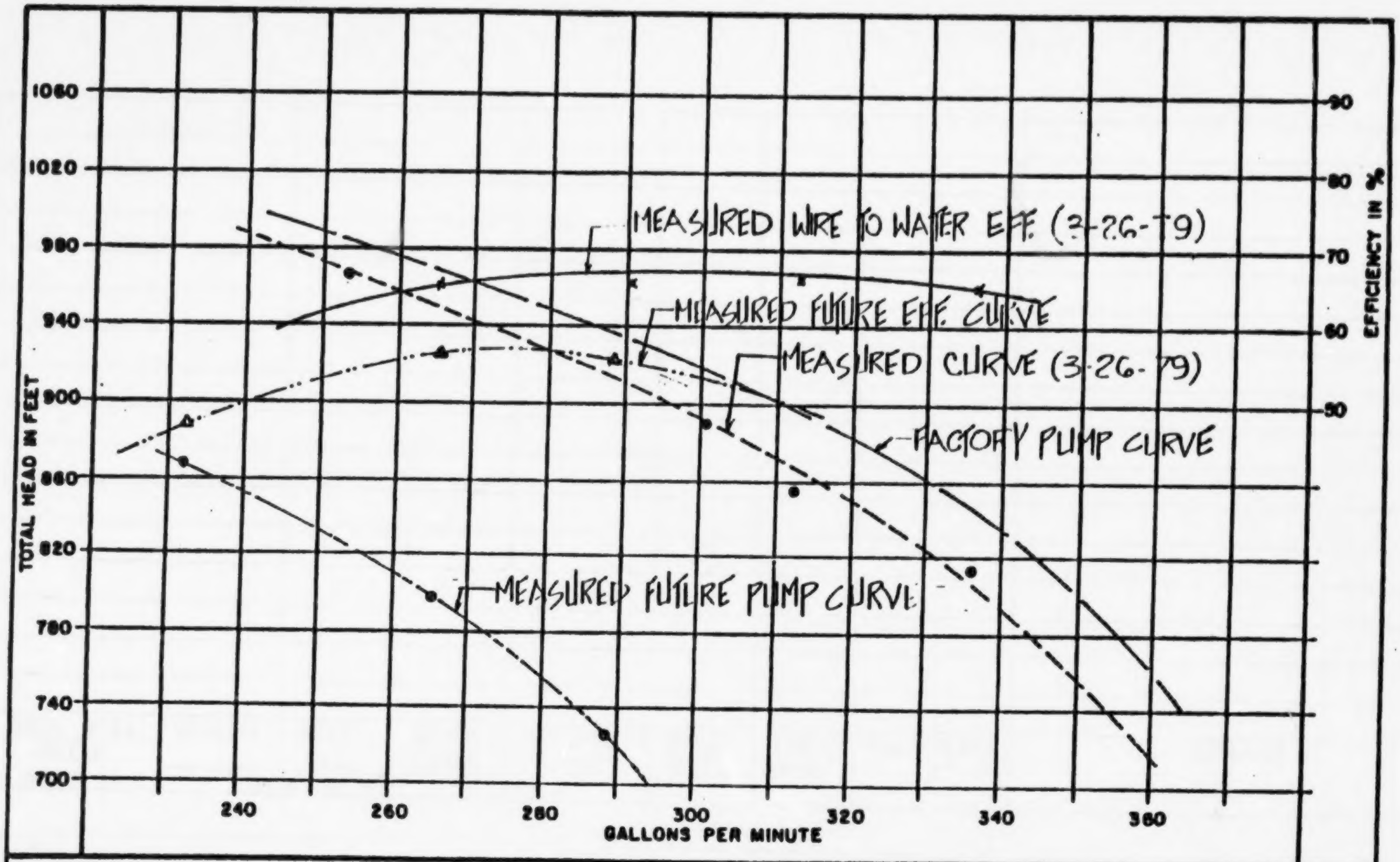
ACOG
MUNICIPAL RECORDS



CITY OF
DATE: 26/Day 3/Mo. 79/Yr.
WELL NO. Y-8

POSSIBLE FUTURE CURVE NO. 1

ACOG
MUNICIPAL RECORDS



CITY OF
DATE: 26 Day 3 Mo. 79 Yr.
WELL NO. Y-8

POSSIBLE FUTURE CURVE NO. 2

A C O G
MUNICIPAL RECORDS

EEI 5-15-80

ACOG MUNICIPAL WELL RECORDS

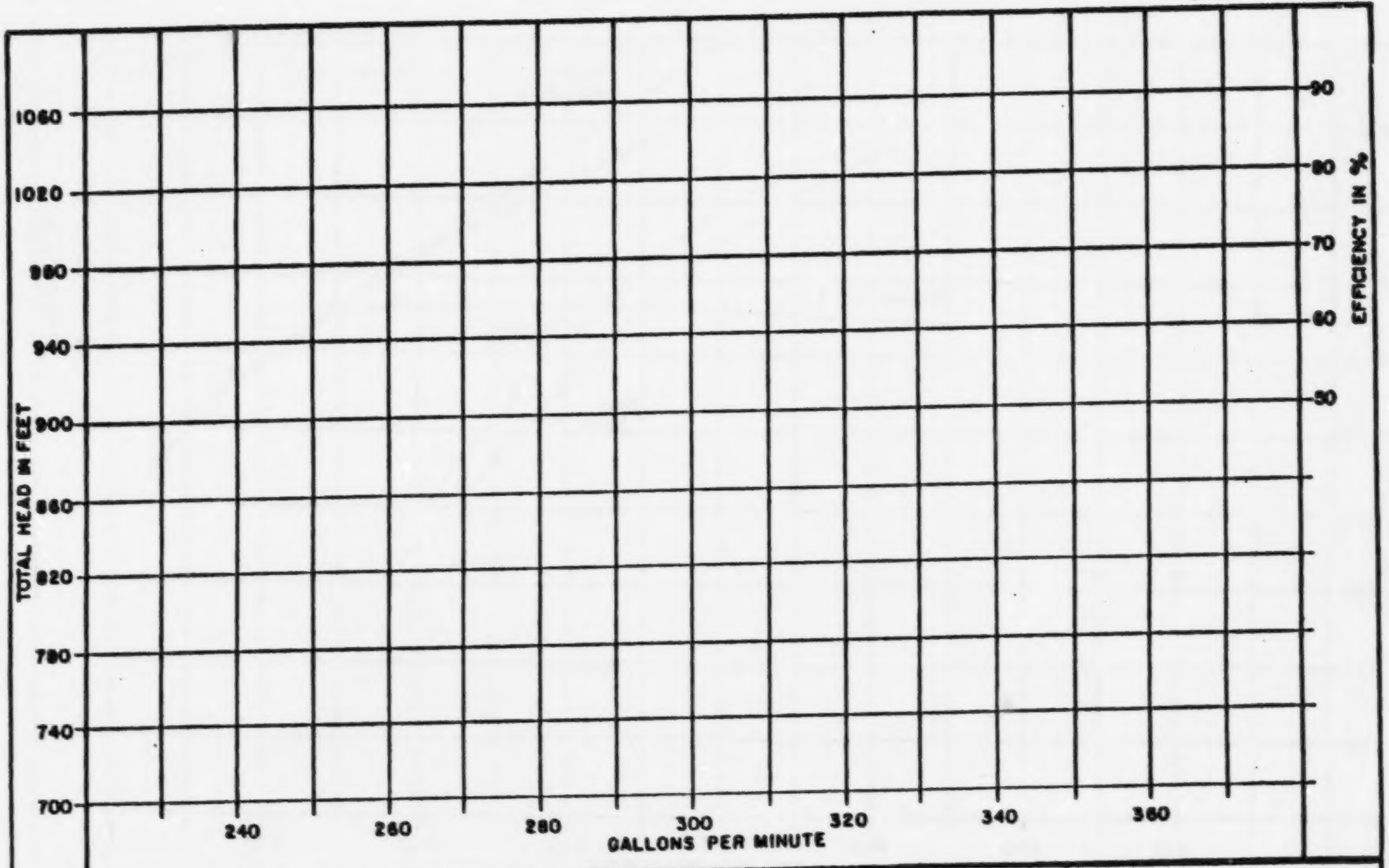
CITY ____________

WELL FIELD MONITORING
PUMP TEST DATA

WELL #____________________ DATE______________________ METER CONSTANT________________

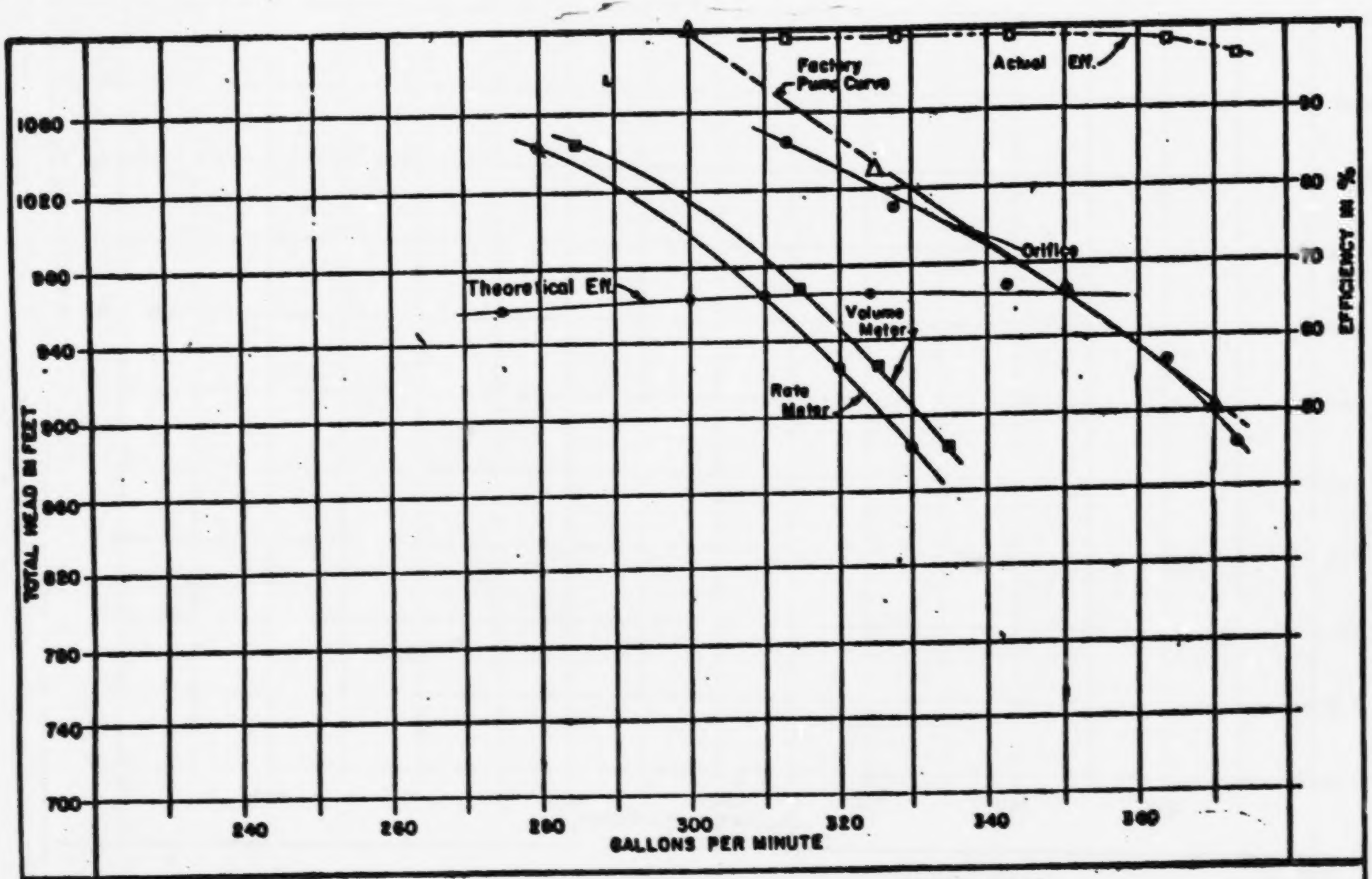
TIME	DEPTH TO WATER		PUMPING RATE			LINE PRESSURE	POWER USAGE	TOTAL HEAD	% EFFICIENCY	REMARKS
	GAGE	FEET	ORIFICE	RATE METER	VOLUME METER					

NOTES:



CITY OF
DATE: ____ ____ ____
Day Mo. Yr.
WELL NO.

A C O G
MUNICIPAL RECORDS



CITY OF YUKON, OKLA.
DATE: 28 Mar. 79
Day Mo. Yr.
WELL NO. Y-P-6

NOTE: Efficiency has been calculated wire to water.

ENGINEERING Enterprises, Inc.
1[illegible] W. MAIN, SUITE [illegible]
NORMAN, OKLAHOMA [illegible]
PHONE (405) [illegible]

WASTE TREATMENT
WATER SUPPLY
POLLUTION
IRRIGATION
LAND DEVELOPMENT

EQUIPMENT

ORIFICE TABLES

For measurement of water through pipe orifices with free discharge

The following tables have been compiled by the Engineering Department of Layne and Bowler, Incorporated, from [illegible] and additions by Purdue University

Note: Capacities are given in nearest whole numbers

—Courtesy Layne & Bowler, Inc.

ORIFICE TABLES

Note: Capacities are given in nearest whole numbers

ENGINEERING Enterprises, Inc. 1225 West Main - Suite 215 Norman, Oklahoma 73069 (405) 329-8300

PROJECT ACOG

SUBJECT DESCRIPTION OF ORIFICE WEIR

PROJECT NUMBER

BY MT DATE 6-18-80

PAGE 1 OF 4

FLOW MEASUREMENT

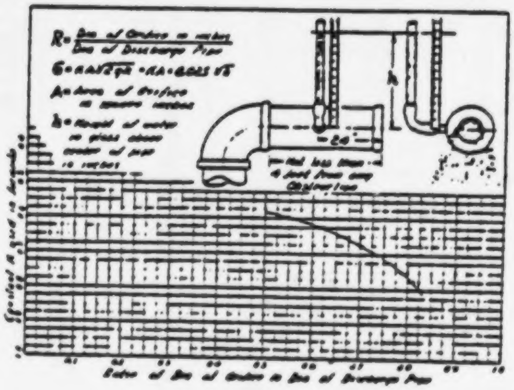
The Orifice Method of Measuring Water Flow

The orifice method is a simple way to measure flow of water from a pipe discharging horizontally into the open air. The sketch shows the general arrangement.

A plate or cap is affixed to the end of the pipe with the circular orifice in the exact center of the pipe. The size of orifice should be from one-half to three-quarters of the size of the pipe, but must be of such size that it will run full of water.

A hole for ⅛" pipe should be drilled and tapped 24" back from the orifice and a short ⅛" nipple screwed in until the inner end is exactly flush with the inner wall of the pipe. One end of a piece of rubber hose is slipped over the end of the nipple and the other end over a glass tube, which should be supported in a vertical position.

Ratio R is the diameter of the orifice divided by the inside diameter of the pipe, and the proper value of K is found from the curve. In the formula A is figured as the area of the orifice in square inches, G=32.2, and H is read as the height in inches of the water in the glass tube above the center of the pipe. Gallons per minute (g) then can be figured.



For convenience when determining capacities during pumping tests, tables for various orifices, covering readings at one-half inch intervals, are given

The following page shows a design of an orifice weir suitable for a pumping test. This particular design is nearly symmetrical when the PVC extension is removed. The symmetry allows the weir to be used in either direction with a change of ½" fittings. The change of fittings may be necessary if the nipple fails to operate properly at one of the tapped holes.

The weir is made of PVC pipe which is considerably less in weight than a metal weir would be. This allows the weir to be manipulated into place with less trouble. The PVC weir is also more economical than the metal design. However, any design which incorporates the described guidelines of the weir is acceptable.

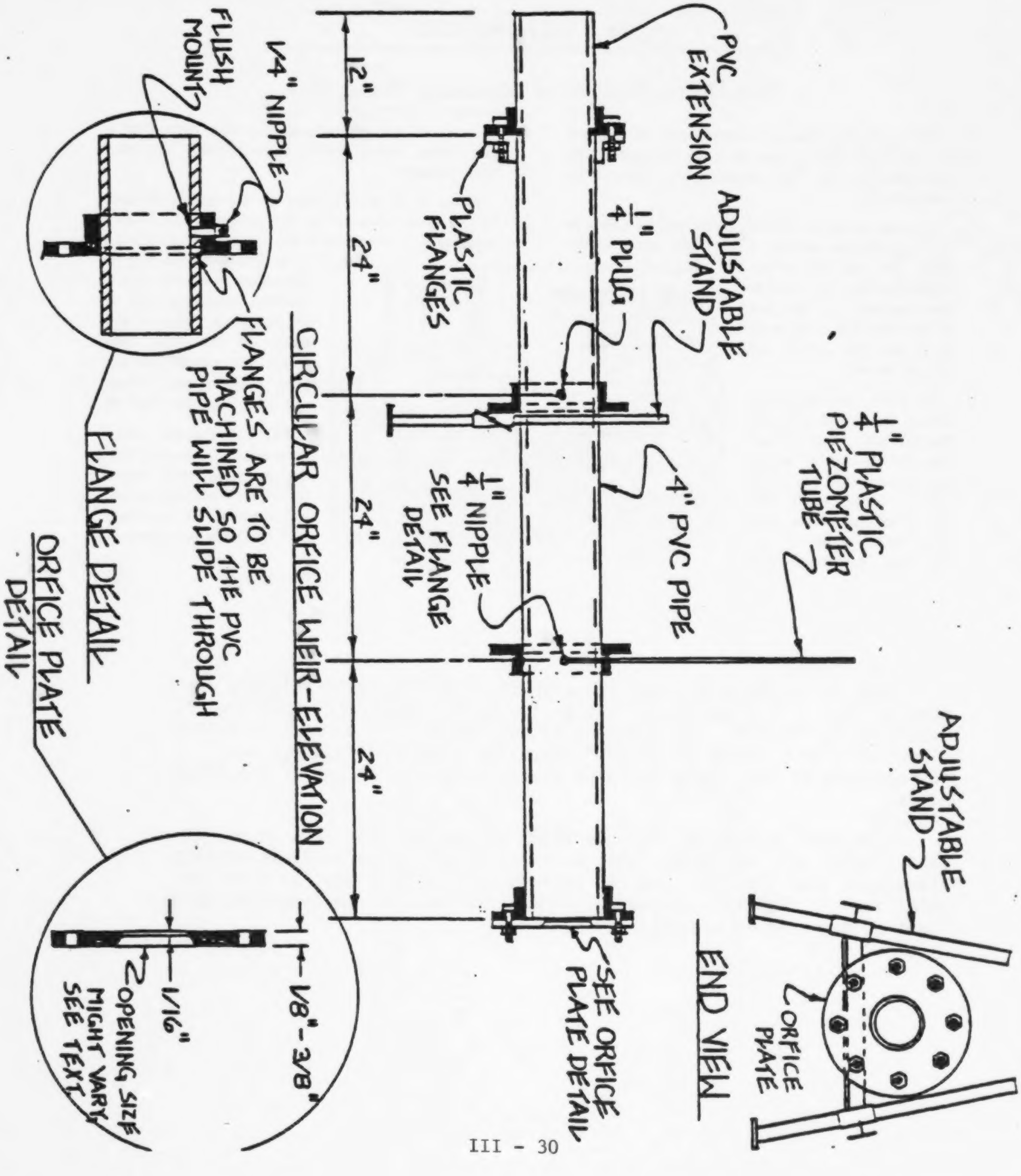
DIAGRAM II

ENGINEERING Enterprises, Inc. 1225 West Main - Suite 215 Norman, Oklahoma 73069 (405) 329-8300

PROJECT ACOG PROJECT NUMBER

SUBJECT CIRCULAR ORFICE WEIR BY MT DATE 6-16-80

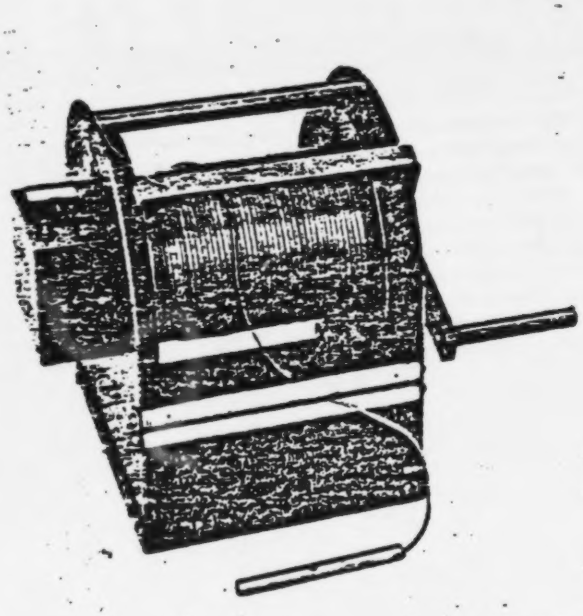
PAGE 2 OF 4


PVC EXTENSION
ADJUSTABLE STAND
1/4" PLUG
PLASTIC FLANGES
12"
24"
24"
24"
1/4" PLASTIC PIEZOMETER TUBE
4" PVC PIPE
1/4" NIPPLE SEE FLANGE DETAIL
CIRCULAR ORFICE WEIR-ELEVATION
FLUSH MOUNT
1/4" NIPPLE
FLANGES ARE TO BE MACHINED SO THE PVC PIPE WILL SLIPE THROUGH
FLANGE DETAIL
ORFICE PLATE DETAIL
1/8"-3/8"
1/16"
OPENING SIZE MIGHT VARY SEE TEXT.
SEE ORFICE PLATE DETAIL
END VIEW
ADJUSTABLE STAND
ORFICE PLATE

weekly

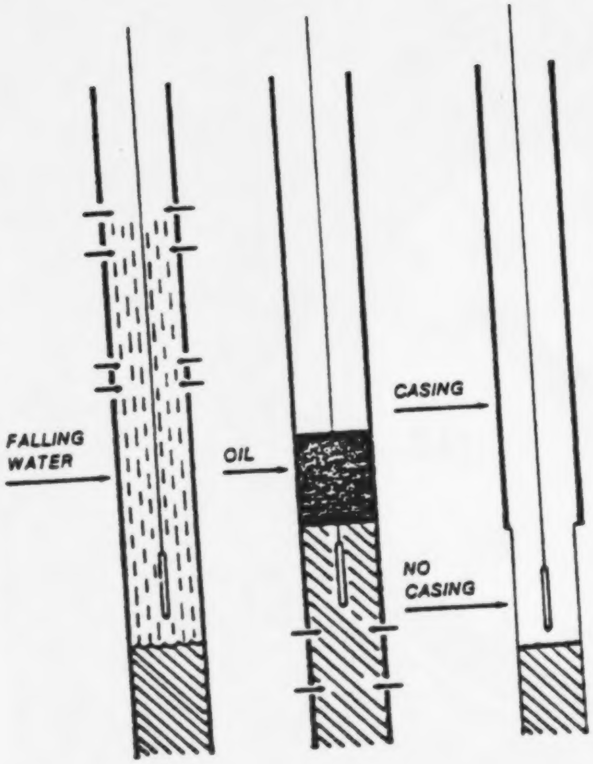
MODEL WLX WATER LEVEL INDICATOR

- **Standard lengths: 1000 and 1500 feet**
- **Brass type diameter ⅜" electrode**
- **Sturdy metal stand type reel**
- **Cable brake control**
- **High tensile strength cable tagged every five feet**
- **Self-contained battery power supply**
- **Readings in high or low mineral water**



M-Scope® Model WLX Water Level Indicator

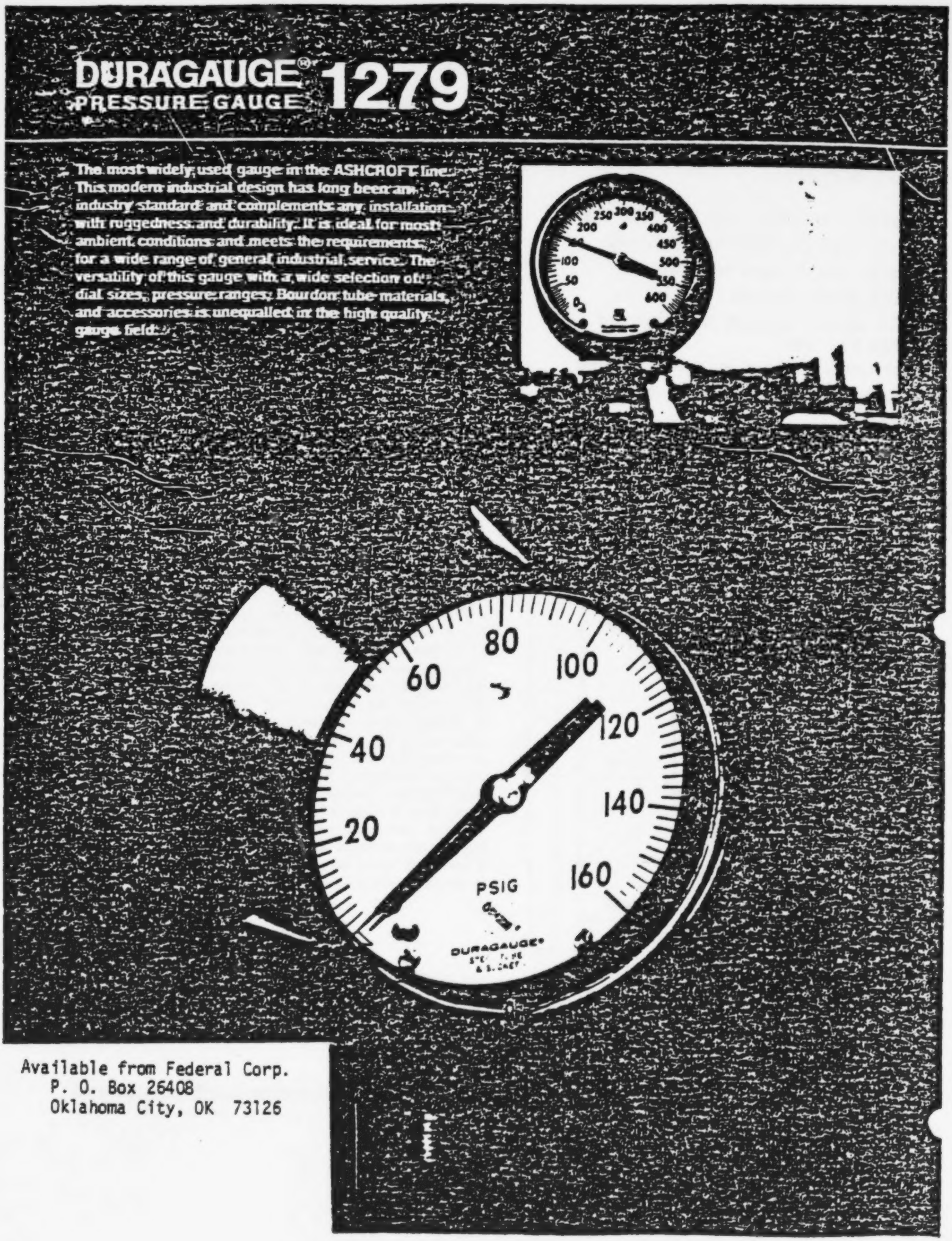
This unit operates on the same principle as the regular Water Level, but uses a geophysical reel to hold the cable. The indicating unit, including the battery power supply, is mounted on the left-hand side of the reel, and can easily be observed by the operator as the cable is lowered into the well. A weighted electrode with only ⅜" diameter gives assurance that there is no slack in the cable when taking deep readings. An additional feature is a selector switch on the indicating unit to permit the taking of readings in highly saline wells, but also in wells with very low mineral contents or soft water. No ground connection is required and the WLX will operate on cased or non-cased wells. The insulated two-conductor high tensile strength cable is calibrated at intervals of 5 feet with metal tags. These instruments are available in standard lengths of 1000 feet or 1500 feet.



The design of all WL and WLX electrodes permits trouble-free operation in wells with falling water, heavy oil slicks and regardless of whether or not a well is cased.

Your M-SCOPE® dealer is:

Fischer Research Laboratory
1005 I Street
Los Banos, California 93635



DURAGAUGE® PRESSURE GAUGE 1279

The most widely used gauge in the ASHCROFT line. This modern industrial design has long been an industry standard and complements any installation with ruggedness and durability. It is ideal for most ambient conditions and meets the requirements for a wide range of general industrial service. The versatility of this gauge with a wide selection of dial sizes, pressure ranges, Bourdon tube materials, and accessories is unequalled in the high quality gauge field.

200
250
300
350
400
450
500
550
600
150
100
50
0
80
60
100
120
40
140
20
160
PSIG
DURAGAUGE®

Available from Federal Corp.
P. O. Box 26408
Oklahoma City, OK 73126

Appendix IV

Suggested Oil and Gas
Ordinance

GARBER-WELLINGTON ASSOCIATION
TITLE

OIL AND GAS WELLS

Oil and Gas Regulations

Sections:

2.010 Intent and Purpose.
2.020 Definitions.
2.030 Permits.
2.040 Application and Filing Fee.
2.050 Issuance or Refusal of Permit.
2.060 Permittee's Insurance and Bond.
2.080 Enhanced Recovery and Saltwater or Deleterious Substances Disposal Wells.
2.090 Annual Fee to Operate.
2.100 Disposal of Salt Water.
2.110 Compliance with Applicable Laws.
2.120 Surface Casing.
2.140 Abandonment and Plugging.
2.160 Well Location.
2.170 Fences.
2.180 Noise and Other Nuisances.
2.190 Facilities.
2.200 Storage Tanks and Separators.
2.210 Fire Prevention.
2.220 Pits.

GWA 1-13-82

2.225 Retaining Walls
2.230 Motive Power.
2.240 Derrick and Rig.
2.260 Drilling Operations - Equipment.
2.265 Moving of Drilling Rig.
2.270 Streets and Alleys.
2.280 Flaring of Gas.
2.290 Fracture and Acidizing.
2.300 Swabbing and Bailing.
2.310 Rupture in Surface Casing.
2.320 Depositing Oil Products.
2.330 Safety Precautions.
2.350 Water for Muds.
2.360 Oil and Gas Inspector.
2.370 Service Companies.
2.380 Accumulation of Vapor.
2.390 Inspection of Pressure Lines.
2.400 Ingress and Egress.
2.410 Order to Cease Operations.
2.420 Appeals.
2.425 City Council Review of Permit Recommendations.
2.430 Conduits on Streets and Alleys.
2.440 Annual Fee for Conduits.
2.450 Applicability to Existing Operations.
2.455 Informal Complaints
2.460 Penalties.

2.010 Intent and Purpose. Whereas the imprudent operation of an oil and gas facility can constitute a menace to the public health, safety and welfare of the City of _______________,it is the intent and purpose of this Chapter that oil and gas operations be reasonably regulated for the public good.

2.020 Definitions. For the purpose of this Chapter, the following definitions shall apply:

(a) "City shall mean the Municipality of ______________, Oklahoma;

(b) "City Council" shall mean the governing body of the City;

(c) "Mayor" shall mean the chief elected official of the City;

(d) "City Manager" shall mean the chief administrative officer of the City;

(e) "State" shall mean the State of Oklahoma, its branches, departments, agencies, boards or the officers thereof;

(f) "Person" shall mean and include any person, firm, partnership, association, corporation, trust, cooperative, or other type of organization;

(g) "Permittee" shall mean the person to whom is issued a permit or permits under the terms of this chapter;

(h) "Well" shall mean, unless specifically qualified, any hole or holes, bore or bores, to any depth for the purpose of producing and recovering any oil, gas or liquified petroleum matter or deleterious substances, or for the injection or disposal of any of the foregoing;

(i) "Natural production" shall mean the raising to the surface of the earth, by natural flow, petroleum or natural gas;

(j) "Artificial production" shall mean the raising to the surface of the earth, by means other than natural flow, petroleum or natural gas;

(k) "Deleterious substance" shall mean any chemical, salt water, oil field brine, waste oil, waste emulsified oil, basic sediment, mud or injurious substances produced or used in the drilling, development, producing, transportation, refining and processing of oil, gas or condensate;

(l) "Pollution" shall mean the contamination or other alteration of the physical, chemical, or biological properties of any natural waters of the City, or such discharge of any liquid, gaseous or solid substance into any water of the City as will or is likely to create a nuisance or render such waters harmful or detrimental or injurious to public health, safety, or welfare; to domestic, commercial, industrial, agricultural, recreational, or other beneficial uses; or to livestock, animals or aquatic life;

(m) "Water", "Waters of the City" or "City Water" shall mean all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations or water, surface and underground, natural or artificial, public or private, which are contained within, flow through or border upon the City or any portion thereof;

(n) "Pressure maintenance" shall mean an operation by which gas, water or other fluids are injected into a supply of oil to maintain pressure or retard pressure decline therein for the purpose of facilitating recovery therefrom, and which has been approved by the Corporation Commission after notice and hearing.

(o) "Enhanced Recovery" shall mean an operation by which fluid or energy is introduced into a source of supply for the purpose of facilitating recovery therefrom:

(p) "Corporation Commission" shall mean the Oklahoma Corporation Commission;

(q) "All technical or oil and gas industry words or phrases used herein and not specifically defined herein shall have that meaning customarily attributable thereto by prudent operators in the oil and gas industry;

(r) "Oil and Gas Inspector" shall mean that person, firm or corporation qualified and employed by the City of ____________ to enforce the provisions of this ordinance, or by his/her authorized representatives;

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(s) "Abandoned well" shall mean; (1) each well in which no production casing has been run, and for which drilling or testing operations have ceased for thirty (30) consecutive days, or; (2) any other well for which there is no current city permit.

(t) "Salt water" as used in this ordinance shall mean any water containing more than 500 mg/1 chlorides.

(u) "Treatable water" shall mean surface and subsurface water in its natural state which may or may not require treatment to be useful for human consumption, and contains less than 10,000 ppm total dissolved solids and/or 5,000 ppm chlorides.

2.030 Permits. It shall be unlawful and an offense for any person acting for himself or acting as agent, servant, employee, subcontractor, or independent contractor of any other person, to well within this City, or to work upon or assist in any way in the production or operation of any such well, without a permit having first been issued by the authority of the Oil and Gas Inspector in accordance with this Chapter.

2.040 Application and Filing Fee.

A. Every application for a permit to drill an original well or to re-enter an abandoned well shall be in writing, signed by the applicant or by some person duly authorized to sign same on his behalf, and it shall be filed with the Oil and Gas Inspector and be accompanied by a filing fee of Three Thousand Five Hundred Dollars ($3,500.00) No application shall request a permit to drill more than one well. The application shall contain full information required by the Oil and Gas Inspector, including the following:

(1) Name and address of applicant and date of application;

(2) Where applying for a proposed original well:

(a) A block map of the ten (10) acres surrounding the drill site, including thereon the location of the proposed well, and distance therefrom to all existing dwelling-houses, buildings, or other structures, designed for the occupancy of human beings or animals, within three hundred (300) feet of any such well, and the location of all existing oil, gas or fresh water wells within said ten (10) acre tract.

(b) The names of the mineral, surface and lease owners.

(3) A drilling prognosis, to specify in detail the amount, weight, and size of conductor pipe and surface pipe and the procedures to be used for cementing such. Plugging procedures to be used in the event production is not established shall also be specified.

(4) A statement of the provisions for water for the drilling rig.

(5) A written plan for disposal of deleterious substances produced during the drilling operations and any deleterious substances produced as a result of production from the well. This plan shall include the method of transportation and name of transporter or transport contractor for the deleterious substances and the name and location of the permitted disposal site, including a copy of the permit for the disposal site and a contract with the owner of the permitted site for the disposal of said deleterious substances, or in the alternative, provide proof of ownership of the permitted disposal site. The permittee shall provide monthly reports to the City of the amount of saltwater and other deleterious substances produced, along with receipts for disposal of same.

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(6) The name and address of the person within the State of Oklahoma upon whom service of process upon applicant may be made within this State; and in the case of any non-resident person who has no such service agent within this State, there shall be attached to the application the designation of such a service agent resident in Oklahoma County, Oklahoma, and a consent that service of summons may be made upon such person in any action to enforce any of the obligations of the applicant hereunder.

(7) A verification of the above information by the applicant hereunder.

B. A copy of the approved Drilling Permit from the Corporation Commission and a copy of the staking plat shall be filed with the City prior to issuance of the municipal permit.

C. Where the application is one for the re-entry of an abandoned well, said application shall contain all the information required by Section 2.040 A. above, with the exception that the Oil and Gas Inspector may vary the requirements thereof to suit the application before him. Provided, that such an application for a permit to re-enter an abandoned well shall provide the following information in every case:

(1) A statement of:
    (a) The then condition of the well;
    (b) The depth to which it is proposed such well shall be deepened;
    (c) The proposed casing program to be used in connection with the proposed deepening; and

(2) Evidence of adequate current tests showing that the casing strings currently passed the same tests that are

required in the case of the drilling of an original well.

2.050 Issuance or Refusal of Permit.

A. The Oil and Gas Inspector's office within thirty (30) business days after the filing of an application for a permit under this ordinance shall determine whether or not said application complies in all respects with the provisions of this ordinance and applicable Federal and State law, and, if it does, shall recommend to the Mayor and City Council that the permit be issued. Each permit issued under the terms of this ordinance shall:

(1) By reference have incorporated therein all the provisions of this ordinance with the same force and effect as if this ordinance were copied verbatim therein;
(2) By reference have incorporated therein all the provisions of applicable State law and the rules, regulations and standards adopted in accordance therewith relating to the protection of human beings, animals, and natural resources;
(3) Specify that the term of said permit shall be for a period of one (1) year from the date of issuance thereof, and for like periods thereafter upon the successful inspection of the permittee's well and operations, as is provided for elsewhere herein;
(4) Specify such conditions imposed by the Oil and Gas Inspector as are by this ordinance authorized;
(5) Specify that no actual operations shall be commenced until the permittee shall file and have approved the required bonds and certificate of insurance in the appropriate amounts as provided for elsewhere herein.

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B. If the permit be issued, it shall, in two (2) originals, be signed by the Oil and Gas Inspector and the permittee, and when so signed shall constitute the permittee's license to drill and operate in the City and the contractual obligation of the permittee to comply with the terms of such permit, such bonds as are required, and applicable State law, rules, regulations, standards and directives. One executed original copy of said permit shall be retained by the Oil and Gas Inspector; the other shall be retained by the permittee and shall be kept available for inspection by any City or State law enforcement official who shall demand to see same.

C. If the permit be refused, or if the applicant notifies the Oil and Gas Inspector in writing that he does not elect to accept the permit as tendered and wishes to withdraw his application, or if the bonds of the appliant be not approved, then upon the happening of any of said events the cash fee filed with the application shall be refunded to the applicant, except that there shall be retained therefrom by the City the sum of Two Hundred Dollars ($200.00) as a processing fee.

2.060 Permittee's Insurance and Bond. In the event a permit shall be issued by the Oil and Gas Inspector, no actual operations shall be commenced until the permittee shall file with the City bonds and a certificate of insurance as follows:

A. A bond in the principal sum of at least Twenty-five Thousand Dollars ($25,000.00). Said bond shall be executed by a reliable insurance company authorized to do business in the State, as surety, and with the applicant as principal, running to the City for the benefit of the City and all persons concerned, conditioned that the permittee will comply with the terms and conditions of this Chapter in the operation of the well for either natural or artificial production, injection or disposal. Said bond shall become effective on or before the date the same is filed with the City and remain in force and effect for at least twelve (12) months subsequent to the expiration of the permit term, and in addition the bond will be conditioned that the permittee will promptly pay fines, penalties and other assessments imposed upon the permittee by reason of his breach of any of the terms, provisions and conditions of this Chapter, and that the permittee will promptly restore the streets, sidewalks and other public property of the City which may be disturbed or damaged in permittee's operations, to their former condition; and that the permittee will promptly clear all premises of all litter, trash, waste, and other substances, and will, after abandonment, grade, level and restore said property to the same surface condition, as practicable as is possible, as existed prior to commencing operations; and further that the permittee shall indemnify and hold harmless the City from any and all liability attributable to granting the permit.

If, after the completion of a producing well, permittee has complied with all of the provisions of this Chapter, such as removing derrick and clearing the premises, he may apply to the Oil and Gas Inspector to have said bond reduced to a sum of not less than Ten Thousand Dollars ($10,000.00) for the remainder of the time said well produces without reworking. During reworking operations the amount of the bond shall be increased to the original amount.

B. In addition to the bond required in paragraph A. of this section, the permittee shall obtain a bond in the principal sum of at least One Million Dollars ($1,000,000.00) Said bond shall be executed by a reliable insurer licensed to do business in the State, as surety, and with applicant as principal, all persons concerned, conditioned that the permittee will comply with every applicable Federal and State law, rule, regulation, standard or directive relating to the maintenance of the safe and beneficial physical, chemical and biological properties of any natural waters of the City; that the permittee shall obtain the necessary permits from the City and State with regard to any operations which have the potential of rendering such waters harmful or detrimental or injurious to the public health, safety and welfare; that the permittee shall bear all the costs necessary and incidental to the correction of any pollution to said waters caused by the permittee or permittee's agents, servants, employees, subcontractors or independent contractors; that the permittee shall pay all fines, penalties, assessments or judgment resulting directly or incidentally from the permittee's activities and which result in pollution of City waters; that the permittee shall indemnify and hold harmless the City from any and all liability resulting from the pollution of City waters.

C. In addition to the bonds required in paragraphs A. and B. of this section, the permittee shall carry a policy or policies of standard comprehensive public liability insurance, including contractual liability covering bodily injuries and property damage, naming the permittee and the City, issued by an insurer authorized to do business within the State, said policy or policies in the aggregate shall provide for the following minimum coverage:

(1) Bodily injuries, One Hundred Thousand Dollars ($100,000.00) per person; Three Hundred Thousand Dollars ($300,000.00) per accident.
(2) Property damage, Two Hundred Thousand Dollars ($200,000.00).

Permittee shall file with the City certificates of said insurance as above stated, and shall obtain the written approval thereof of the Oil and Gas Inspector who shall act thereon promptly after the date of such filing.

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Said insurance policy or policies shall not be cancelled without written notice to the Oil and Gas Inspector at least ten (10) days prior to the effective date of such cancellation. In the event said policy or policies are cancelled, the permit granted shall immediately thereupon terminate without any action on the part of the Oil and Gas Inspector, and permittee's rights to operation under said permit shall cease until permittee files additional insurance as provided herein.

If, after completion of a producing well, the permittee has complied with all of the provisions of this ordinance, such as removing derricks, clearing premises, and the like, he may apply to the Oil and Gas Inspector to have said insurance policy or policies reduced as follows: Bodily injuries, Fifty Thousand Dollars ($50,000.00) per person, One Hundred Thousand Dollars ($100,000.00) per accident; and property damage, Fifty Thousand Dollars ($50,000.00).

2.080 Enhanced Recovery and Saltwater or Deleterious Substances Disposal Wells.

A. No person shall re-enter any well or drill an original well to be used for enhanced recovery or disposal of saltwater or other deleterious substances without first obtaining the necessary permit therefor. Such permit shall consist of (2) two separate parts, i.e., A. Permit to drill or re-enter and construct, and B. Permit to operate.

B. An application for the permit to drill or re-enter a well for enhanced recovery or substance disposal shall be in the same form as that required for a permit to drill an original well, and shall contain complete information required by the Oil and Gas Inspector, including the following:

(1) A block map of the well site, showing all equipment to be used thereat, location of pipelines, access road, and distances from the well to any and all fences, public roadways, and buildings within a radius of three hundred thirty (330) feet;

(2) A block map of the project, showing the location of; (a) all water supply wells within a 1/4 mile radius of each injection or disposal well; (b) all public water supply wells, disposal wells, injection wells, producing wells and plugged and abandoned wells within the project area and those sections immediately adjacent; (c) all conduits, and; (d) tank battery, pumping station and appurtenant equipment.

(3) All wells within the project area and those sections immediately adjacent shall be indicated by status (e.g., plugged and abandoned, injection, salt water, oil, etc.), and show the following additional information;

  (a) Footage location (surface casing)
  (b) Derrick floor and ground level elevation;
  (c) Drilled total depth;
  (d) Packer body total depth;
  (e) Size, depth and quality of surface and production casing, including zones from which casing has been removed;
  (f) Location of all plugs, packers, cement plugs, tubing anchors, etc., with the well bore;
  (g) Depth and nature of all cement squeeze jobs;
  (h) Formation name and depth of all open perforations in a producing open hole;
  (i) Volume and type of cement used on surface and production strings;
  (j) Top of cement.

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(4) One copy of all electric, mechanical, sample and driller's logs, if available;

(5) Fee and operation name for each well;

(6) One copy of all cement bond logs and production logs;

(7) One copy of all work performed on the well;

(8) Copies of all information supplied to the Corporation Commission, and said Commission's approval of the project;

C. Upon the completion of the application required hereunder, the Oil and Gas Inspector shall have thirty (30) business days to review same and make a recommendation of approval or disapproval to the Mayor and City Council.

D. Prior to placing any enhanced recovery or substance disposal well into service, a permit to operate such well shall be obtained from the Oil and Gas Inspector. Every application for a permit to operate such well shall contain the following information:

(1) Depth to static water level (hydrostatic head). Such data shall be obtained by means of a method approved by the Oil and Gas Inspector. Such data shall be obtained not less that forty-eight (48) hours after openings have been made through the casing into the injection disposal zone or zones.

(2) Based on the static water level identified in the previous paragraph, maximum operating pressures and rates of injection shall be established and maintained so as to prevent the hydraulic pressure level at a radius of ten (10) feet from the injection or disposal wells from rising above the base elevation of treatable water. Such maximum operating pressures and injection rates shall be noted on the permit. No injection or

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disposal well will be permitted to operate if the well's zone of influence will exceed the above referenced limits.

E. A fee in the sum of One Thousand Dollars ($1,000.00) shall be submitted along with every application for a permit to operate an injection or substance disposal well.

F. Copies of Corporation Commission Form No. 1015, indicating successful pressure testing of each injection well at a pressure greater than the maximum proposed for the project, or if no such Form No. 1020 has been filed and approved, then sufficient evidence of the successful pressure testing of each injection well shall be filed with the Oil and Gas Inspector.

G. Every such injection or disposal well shall be constructed so as to seal the injection zone from the upper portion of the casing. The annulus between the injection tubing and the casing shall be filled with a noncorrosive fluid, then sealed and a one-fourth (1/4) inch female fitting with cut off valve shall be attached so that the pressure in the annulus may be measured by the oil and gas inspector by attaching a guage having a one-fourth (1/4) inch male fitting. A pressure shall be maintained in the annulus sufficient to monitor the fluids in the annulus. Any significant deviation from the established pressure shall be cause to shut down the well, and may result in cancellation of the operating permit, until such time as the established pressure can once again be maintained.

H. Injection lines shall be buried in a trench of a depth no less than four (4) feet, and shall be pressure tested (static) annually at a minimum of 150% of the pressure normally encountered at the injection pump discharge for a period of hours to be fixed by the Oil and Gas Inspector. Said Oil and gas Inspector shall be notified five (5) days in advance of such test and may supervise same. Test results shall be filed with the City upon completion.

I. Domestic and public water supply wells located within a radius of one-quarter (1/4) mile of any enhanced recovery or disposal well shall be tested prior to beginning injection or disposal and thereafter semi-annually for the presence of deleterious substances, such as chlorides, sulphates and dissolved solids. Such testing is the responsibility of the permittee and at permittee's expense, to be conducted by a person approved by the Oil and Gas Inspector. Said Oil and Gas Inspector shall be notified five (5) days in advance of such testing and may be present therefore. Test results shall be filed with the City upon completion.

2.090 Annual Fee to Operate. An annual inspection fee is hereby levied upon each well operated or maintained under a permit issued by the City; such fee shall be in the amount of Two Hundred Fifty Dollars ($250.00), payable to the City on or before the annual anniversary date of the issuance of any permit under this ordinance. No permit for any well shall be considered valid for any year for which the annual fee has not been paid. Failure to pay any required permit fee within thirty (30) days of a delinquent notice sent to the latest address provided by the permittee will result in cancellation of said permit.

2.100 Disposal of Salt Water.

A. Every permittee under this Chapter shall be responsible for the safe disposal of salt water or other deleterious substances which he may bring to the surface of the earth and shall provide a plan for such disposal as required in 2.040 A. (6). Such disposal shall not result in pollution of the waters of the City and shall not result in any other environmental hazard, and shall incorporate the best available techniques and equipment.

B. In the event of any leakage or spillage of any pollutant or deleterious substance, whatever the cause thereof, the permittee shall cause the Oil and Gas Inspector to be notified thereof promptly. If, in the judgment of the Oil and Gas Inspector, such leakage or spillage represents a potential environmental hazard, he may issue whatever corrective orders he deems appropriate, and additionally may require the appropriate testing of the surface and subsurface for pollutant incursion, the cost of such test or tests to be borne by the permittee.

C. No person shall dispose of saltwater or other deleterious substance in any lined or unlined earthen pit within the city limits.

D. No person shall inject any saltwater or other deleterious substance into the annulus between the inside of the surface casing string and the next inside casing string, except when the bottom of the properly cemented surface casing extends 200' or more through or into a continuous impermeable clay barrier below the base of treatable water.

2.110 Compliance with Applicable Laws. No person shall drill an original well or re-enter an abandoned well for any purpose, or permit to exist any well, structure, equipment, pipeline, machinery, tank or other appurtenance, in violation of any of the provisions of this ordinance or other City ordinances as may be applicable, or the laws, rules, regulations, operative standards or directives of the State.

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2.120 Surface Casing.

A. i. Surface casing shall be set a minimum of two hundred feet below the deepest encounter of treatable water found in eight (8) sections adjacent to the section in which the well is located. Logs which identify the base of treatable water, shall be run in the surface hole before the surface pipe is set. A copy of such logs shall be filed with the Oil and Gas Inspector, or; ii. surface casing may be set without the above required logging, provided the applicant can demonstrate to the satisfaction of the Oil and Gas Inspector that the bottom of the surface casing will extend through or into at least 200' of continuous impermeable clay barrier below the base of treatable water, is properly cemented and cement bond logs run with the quality of the cement bond approved by the Oil and Gas Inspector. Surface pipe shall have a centralizer on the shoe joint, and centralizers within fifty (50) feet of the shoe joint, and centralizer no more than two hundred (200) feet apart above the second centralizer.

B. Surface pipe shall be cemented by attempting to circulate good cement to surface by normal displacement practices. If cement cannot be circulated to surface due to washed out hole or lost circulation, the existing cement shall not be over-displaced and a plug shall be left in the bottom of the casing string to be drilled out once the surface is set. The remaining open hole behind the surface pipe shall be cemented by running a tubing string between the conductor string and the surface pipe until the top of the cement is tagged. The remaining uncemented annular space will then be cemented until good cement is circulated to surface. No further drilling shall be accomplished until the cement has set for at least twenty-four

(24) hours, or in the alternative, until samples of the cement have passed independent laboratory tests satisfactory to the Oil and Gas Inspector.

C. Where an existing well is to be used as an injection or disposal site, the existing casing and cement shall be of such integrity and depth as to adequately and safely isolate fresh water producing zones from the seepage or bleeding of injection fluids or disposants. Where additional protective operations are undertaken to comply with his paragraph, the Oil and Gas Inspector shall be notified thereof sufficiently in advance in order for him to be present for such operations.

2.140 Abandoned and Plugging. Whenever any well is abandoned it shall be the obligation of the permittee and the operator of the well to set a two hundred (200) foot cement plug in the bottom of the surface casing, with the bottom of the plug one hundred (100) feet below the surface casing section; and to set a fifty (50) foot cement plug in the top of the surface casing. No surface or conductor string of casing may be pulled or removed from a well. During initial abandonment operations it will be the obligation of the permittee and operator to flood the well with mud-laden fluid weighing not less than nine (9) pounds per gallon, and to circulate this mud until stabilized, and the well shall be kept filled to the top with mud-laden fluid of the weight herein specified, at all times; mud-laden fluid of the above specifications will be left in the well bore below and between cement plugs. Any additional provisions or precautionary measures prescribed by the State or the Corporation Commission of the State in connection with the abandonment and plugging of a well shall be complied with by the permittee.

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2.160 Well Location. No permit shall be issued for the drilling of an original well or the re-entry of an abandoned well at any location which is nearer than two hundred (200) feet of any permanent residence or commercial building, or which is closer than three hundred (300) feet to a producing fresh water well.

2.170 Fences. Any person who completes any well as a producer shall have the obligation to enclose said well, together with its surface facilities, by a fence sufficiently high and properly built so as to ordinarily keep persons and animals out of the enclosure with all gates thereto to be kept locked when the permittee or his employees are not within the enclosure. Provided, that in non-platted areas the Oil and Gas Inspector, at his discretion, may waive the requirement of any fence or may designate the type of fence to be erected. Fences must be kept locked at all times workers of permittee are not present; a duplicate set of keys to said lock shall be filed with the Oil and Gas Inspector.

2.180 Noise and Other Nuisances. All oil operations, drilling and production operations shall be conducted in such a manner as to eliminate, as far as practicable, dust, noise, vibration or noxious odors, and shall be in accordance with the best accepted practices incident to exploration for, drilling for and production of oil, gas and other hydrocarbon substances. Proven technological improvements in exploration, drilling and production methods shall be adopted as they become, from time to time, available, if capable of reducing factors of nuisance and annoyance.

2.190 Facilities. All lease equipment shall be painted and maintained in a good state of appearance, and shall have posted in a prominent place a metal sign no less than two (2) feet square in area upon which the following information shall be conspicuous: Permittee's name; lease name; location of the drill site by reference to the United States survey; identifying number of the permit issued by the City.

2.200 Storage Tanks and Separators.

A. Crude oil storage tanks shall not be constructed, operated or used except to the extent of two (2) steel tanks for oil storage, not exceeding five hundred (500) barrels capacity each and so constructed and maintained as to be vapor tight. Provided, that additional tankage may be approved by the Oil and Gas Inspector.

B. A permittee may use, construct and operate a steel conventional separator and such other steel tanks and appurtenances as are necessary for treating oil with each of such facilities to be so constructed and maintained as to be vapor tight. Each oil, gas separator shall be equipped with both a regulation pressure-relief safety valve and a bursting head.

2.210 Fire Prevention. Adequate fire fighting apparatus and supplies approved by the City Fire Department shall be maintained on the drilling site at all times during drilling and production operations. All machinery, equipment and installations on all drilling sites within the City limits shall conform with such requirements as may from time to time be issued by the Fire Department.

2.220 Pits. Steel mud or circulating pits shall be used. Such pits and contents shall be removed from the premises and the drilling site within fifteen (15) days after completion of the well. Earthen pits will be allowed only as temporary emergency pits and/or as catch basins. Catch basin pits shall be used only for the purpose of catching any deleterious substance runoff and shall be no greater than 320 cubic feet. Such catch basin will be equipped with a liquid level activated pump designed to keep fluids pumped out of such catch basin pit. All such earthen pits must be lined and approved in writing by the Oil and Gas Inspector. Emergency pits shall be emptied as soon as the emergency is over and all such pits shall be emptied and then leveled within fifteen (15) days after completion of the well.

2.225 Retaining Walls. An earthen retaining wall of adequate size for the terrain involved will be constructed on the low side of the well site in the event the well site is located on sloping or unlevel ground. The top of the retaining wall shall be at least level with the top of the base of the Christmas Tree or other wellhead connections on any completed well, or at least level with the ground at the point where surface casing is set in the well when drilling.

An earthen diversion wall of adequate size for the terrain involved shall be constructed on the high side of the wall site in the event the well site is located on sloping or unlevel ground. The diversion wall will be of sufficient height and strength so as to divert runoff waters around the well site.

2.230 Motive Power. Motive power for all well pumping equipment shall be electricity unless otherwise approved by the Oil and Gas Inspector.

2.240 Derrick and Rig. It shall be unlawful and an offense for any person to use or operate in connection with the

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drilling, re-entry or reworking of any well within the City, any wooden derrick or any steam-powered rig, and all engines shall be equipped with adequate mufflers approved by the Oil and Gas Inspector. Permitting any drilling rig or derrick to remain on the premises or drilling site for a period of longer than sixty (60) days after completion or abandonment of a well is hereby prohibited.

2.260 Drilling Operations - Equipment. All drilling, re-entry and operations at any well performed under this ordinance shall be conducted in accordance with the best practices of the reasonably prudent operator. All casing, valves, and blowout preventers, drilling fluid, tubing, bradenhead, christmas tree and well head connections shall be of a type and quality consistent with the best practices of such reasonably prudent operator. Setting and cementing casing and running drill stem tests shall be performed in a manner and at a time consistent with the best practices of such reasonably prudent operator. Any permittee under this ordinance shall observe and follow the recommendations or regulations of the American Petroleum Institute and the Corporation Commission, except in those instances that are specifically addressed by this ordinance. A copy of all logs associated with the surface casing shall be filed with the Oil and Gas Inspector.

2.265 Moving of Drilling Rig. It shall be unlawful and an offense for any person to move or cause to be moved the drilling rig from a well until the hole has been cased or properly plugged unless written permission to do so is obtained from the Oil and Gas Inspector.

2.270 Streets and Alleys. No well shall be drilled, and no permit shall be issued for any well to be drilled at any location which is within any of the streets or alleys of the City; and no street or alley shall be blocked or encumbered or closed in any drilling or production operation except with the written approval of the Oil and Gas Inspector, and then only temporarily.

2.280 Flaring of Gas. All produced gas shall either be sold or flared with the flaring procedures being approved by the Oil and Gas Inspector and the Fire Marshal.

2.290 Fracture and Acidizing. In the completion of oil and gas, injection, disposal or service well, where acidizing or fracturing processes are used, no oil, gas or other deleterious substances or pollutants shall be permitted to pollute any surface or subsurface fresh waters.

2.300 Swabbing and Bailing. In swabbing, bailing or purging a well, all deleterious substances removed from the bore hole shall be placed in appropriate tanks and no substances shall be permitted to pollute any surface or subsurface fresh waters.

2.310 Rupture in Surface Casing. In the event a rupture, break or opening occurs in the surface or production casing, the permittee or the operator or drilling contractor shall take immediate acton to repair it, and shall report the incident to the Oil and Gas Inspector promptly.

2.320 Depositing Oil Products. No person shall deposit, drain or divert into or upon any public highway, street or alley, drainage ditch, storm drain, sewer, gutter, paving, creek, river, lake or lagoon, any oil or oily liquid with petroleum content or any mud, rotary mud, sand, water or salt water, or in any manner permit by seepage, overflow, deliberate release or otherwise, any of such substances to escape from any property owned, leased or controlled by such person and flow or be carried into or upon any public highway, street or alley, drainage ditch, storm drain, sewer, gutter, paving, creek, river, lake or lagoon, within the City.

2.330 Safety Precautions. Persons drilling, operating or maintaining any well shall use all necessary care and take all precautions which shall be reasonably necessary under the circumstances to protect the public. The provisions of this Chapter shall be deemed to be the minimum requirements for the preservation of the public health, safety and welfare, and compliance with the terms hereof shall not be deemed to relieve any persons of any additional duty imposed by law.

2.350 Water for Muds. In the event a fresh water supply well is drilled to provide water for drilling muds, upon the completion of operations for which such well is required, such well shall be plugged by cementing top to bottom, after notice of intention to so plug is provided the Oil and Gas Inspector, who may supervise the operation.

2.360 Oil and Gas Inspector.

A. The City Manager shall employ a qualified person, persons, firm or corporation as an Oil and Gas Inspector, whose duty it shall be to enforce the provisions of this Chapter.

B. The Oil and Gas Inspector shall have the authority to issue such orders or directives as are required to carry out the intent and purpose of this Chapter and its particular provisions. Failure to abide by any such order or directive shall be a violation of this Chapter.

C. The Oil and Gas Inspector shall have the authority to go upon and inspect any premises covered by the terms of this Chapter to ascertain whether this Chapter and the applicable laws, rules, regulations, standards or directives of the State are being complied with. Failure to permit access to the Oil and Gas Inspector shall be deemed a violation of this Chapter.

D. The Oil and Gas Inspector shall have the authority to request and receive any records, specified in this ordinance relating to the status or condition of any well or project or the appurtenances thereof within the City. Failure to provide any such requested material shall be deemed a violation of this Chapter.

2.370 Service Companies. Upon request of the Oil and Gas Inspector, service companies or other persons shall furnish and file reports and records showing perforating, hydraulic fracturing, cementing, shooting, chemical treatment and all other service operations on any site covered by this Chapter. Such furnished material shall remain confidential where such confidentiality is usually granted by the State. Failure to provide any such requested material shall be deemed a violation of this Chapter.

2.380 Accumulation of Vapor. The Oil and Gas Inspector shall have the authority to require the immediate shutting in or closing of any well if he finds that there exists, within a one hundred (100) foot radius of any well, any gas or gasoline vapor in a quantity sufficient to constitute, in his judgment, or in the judgment of the City Fire Marshal, a fire hazard. The well shall remain shut or closed in until the hazard and its cause are removed.

2.390 Inspection of Pressure Lines. The Oil and Gas Inspector shall inspect all pressure lines in use at any well or at any project to assure that tubing, fittings, equipment or connections are reasonably tight, safe and free from leaks.

2.400 Ingress and Egress. Lease roads shall be maintained in such a manner as to safely and comfortably allow for ingress and egress of City or State personnel traveling in a common passenger motor vehicle.

2.410 Order to Cease Operations.

A. If the Oil and Gas Inspector finds that, in his judgment, a hazard to life or natural resources exists, he shall order immediate rectification of the cause. If the permittee takes no immediate measure to reduce the hazard, or if the situation be so perilous as to constitute an imminent threat to safety, then in either of these events he may order the prompt cessation of activity, and if necessary, the clearance of the premises.

B. The Oil and Gas Inspector shall apply to the City Manager for a hearing upon such order, which hearing shall be held not longer than twenty-four (24) hours after the issuance of said order by the Oil and Gas Inspector. The City Manager shall determine if proper cause existed, and, if not, shall order the permittee's activity to resume without delay. If the City Manager determines that proper cause did not exist for the order to cease activity to issue, then he shall make whatever ruling is proper to assure rectification of the cause of the peril. Such ruling and compliance with it by the permittee shall not be construed to absolve the permittee of any liability for any violation of this Chapter or for any damage or injury caused thereby.

2.420 Appeals. Any permittee aggrieved by any order, directive or ruling issued by the Oil and Gas Inspector, or by any ruling by the City Manager may appeal the same to the City Council which shall hear the matter at its next scheduled meeting. The lodging of such appeal shall not stay the enforcement of any of the provisions of this Chapter. The Council, upon hearing the matter, may issue whatever ruling or order is appropriate, provided that such ruling or order be in keeping with the spirit and purpose of this Chapter.

2.425 City Council Review of Permit Recommendations. Upon the consideration of any application for a permit required by the terms of this ordinance, the Oil and Gas Inspector shall recommend approval or disapproval thereof to the Mayor and City Council, who shall review the matter at a regularly-scheduled meeting, and thereupon uphold or reverse the recommendation with or without the addition of any conditions thereto.

2.430 Conduits on Streets and Alleys.

A. No permittee shall make any excavations or construct any lines for the conveyance of fuel, water or minerals, on, under or through the streets and alleys of the City without first having obtained a permit therefor upon application to the Department of Public Works.

B. The Director of Public Works shall prescribe the forms to be used for such application and the information to accompany it.

C. Each application for a permit under this Section shall be accompanied by a non-refundable filing fee in the amount of Two Hundred Fifty Dollars ($250.00).

D. The Director of Public Works shall, within twenty (20) days of receipt of the properly executed application, either grant or deny the request.

E. The granting of any such permit shall not be construed to be the granting of a franchise.

2.440 Annual Fee for Conduits.

A. The permittee under 2.430 of this Chapter shall pay to the City an annual renewal and inspection fee being the total of One Dollar ($1.00) per rod of conduit multiplied by the number of rods in the conduit for which the permit was issued.

B. The Director of Public Works shall appoint a representative who shall inspect such conduits to assure the public safety. No permit issued under 2.430 of this Chapter shall be renewed if the conduit or any part thereof covered by such permit is in an unsafe condition.

2.450 Applicability to Existing Conditions.

A. This Chapter shall apply to any person drilling an original well, re-entering an abandoned well, conducting natural or artificial production projects or operations, or maintaining a disposal well within the City of ______________________________ on the (date)______________________ and every such person shall have no longer than ninety (90) days to come into compliance with this Chapter. Provided that:

(1) No initial permit fees shall be charged such person as would otherwise apply;

(2) No penalties shall be sought against any activity violative of this Chapter where such activity preexisted the adoption of this Chapter and was otherwise in compliance with the applicable State law, rules, regulations, standards or directives.

2.455 Informal Complaints. If, upon information or inspection, it is found that a permittee is violating any portion of this chapter or causing damage or pollution to any surface or underground treatable water the Oil and Gas Inspector shall file a written administrative complaint with the City Manager, a copy of which shall be delivered or mailed to the permittee or his agent. If upon subsequent inspection, it is determined that the permittee has taken the corrective actions specified, the complaint may be dismissed; otherwise, formal application will be made to the City Council for an order revoking the permit, and for any other appropriate remedy; pending the outcome of the final determination of the City Council on the formal application, the Oil and Gas Inspector shall, after an onsite inspection, have the authority to shut down those operations where conditions appear obvious that surface or underground pollution is occurring.

2.460 Penalties. It shall be unlawful and an offense for any person to violate or neglect to comply with any provisions hereof irrespective of whether or not the verbiage of each section hereof contains the specific language that such violation or neglect is unlawful and is an offense. Any person who shall violate any of the provisions of this Chapter, or any of the provisions of a drilling and operating permit issued pursuant hereto, or any condition of the bond filed by the permittee pursuant to this Chapter, or who shall neglect to comply with the terms hereof, shall be fined in a sum not more than One Hundred Dollars ($100.00), and the violation of each separate provision of this Chapter, and of said permit, and of said bond, shall be considered a separate offense, and each day's violation of each separate provision thereof shall be considered a separate offense. In addition to the foregoing penalties, it is further provided that the City Council at any regular or special sessions or meeting thereof, may, provided ten (10) days notice has been given to the permittee that revocation is to be considered at such meeting, revoke or suspend any permit issued under this Chapter and under which drilling or producing operations are being conducted in the event the permittee thereof has violated any provision of said permit, said bond, of this Chapter. In the event the permit be revoked, the permittee may make application to the Oil and Gas Inspector for re-issuance of such permit, and the action of the City of ______________ thereon shall be final. Any continuing offense shall be considered a public nuisance, the remedies for which under law shall be in addition to those hereinbefore enumerated.

GWA 1-13-82

Appendix V

THE ECONOMIC IMPACT OF THE PROPOSED REGULATION OF URANIUM IN DRINKING WATER ON MUNICIPAL WATER AND WASTEWATER TREATMENT FACILITIES IN CENTRAL OKLAHOMA

Gregory L. Wallace, Hydrogeologist
Garber-Wellington Association
Association of Central Oklahoma Governments

Abstract

Recognizing a vital need for a development of a procedure to be utilized locally and nationally, the local elected officials of the Association of Central Oklahoma Governments (ACOG) developed and presented a research program to the Oklahoma Congressional delegation in Washington. This proposal resulted in the authorization and partial funding of a four year comprehensive project to design, develop and implement a plan for the protection and management of the nation's ground water resources. In order to achieve these objectives, ACOG created the Garber-Wellington Association. This Association consists of the Garber-Wellington Policy Committee and the Garber-Wellington Technical Committee. These committees have a steering committee and direct the development of its project and make the management decisions based on conclusions drawn from continuing research. Never before has a research project of this magnitude, involving the beneficiaries and local elected officials, been accomplished.

Research being conducted in central Oklahoma on behalf of the Garber-Wellington Association has documented some potential problems related to uranium in municipal water supplies. The U.S. Environmental Protection Agency is in the process of reviewing possible promulgation of regulations limiting uranium content in drinking water. This authority is granted under Public Law 93-523, the Safe Drinking Water Act, which established the National Interim Primary Drinking Water Regulations which took effect in 1977. These regulations set maximum contaminant levels for several constituents including radionuclides. Currently, 300,000 central Oklahomans are served by several water systems which utilize ground water from the Garber-Wellington Aquifer. The Garber-Wellington is a Permian deltaic sandstone with alternating layers of shale which underlies approximately 9,200 square miles in central Oklahoma.

Research to date has been involved with data collection, ground water quality monitoring, design and implementation of a municipal records keeping system and innovative new techniques in ground water monitoring methodologies. Data accumulated is being utilized for aquifer modeling as a guideline for protection and management of the area's ground water resources with protocol documented so that the benefits of the project can be utilized nationwide. During the first year of the Garber-Wellington Research Study, over 200 municipal wells have been incorporated into a monitoring program with historic information documented on each well.

During subsequent phases of the project, it was discovered that 50% of the 200 municipal wells sampled contain amounts of naturally occuring uranium, 238 in quantities exceeding

the "proposed" EPA drinking water standard limit of 10 pico curies per liter (pc/l).

Alternative sources of potable water are not available in this and other similar regions. If the proposed limit is enforced, the economic effects could financially cripple this area, and a good portion of the Southwestern United States, due to the common occurance of Permian deltaic environments.

Current investigations are underway to document the financial impact of treating the ground water to remove the uranium by conventional methods. The associated costs, while staggering, are insignificant when compared to the requirements necessary for disposal of the uranium after treatment due to the classification of the residue as low level radio-active waste.

If the uranium is not removed prior to water distribution, the burden of treatment will lie within the confines of the wastewater treatment facility. The presence of the uranium in the wastewater magnifies already existing problems with economic disposal of municipal sludge through conventional techniques.

The most practical solution appears to lie in proper monitoring of the network of water wells and special construction techniques to prevent tapping zones of the aquifer which contain high concentrations of uranium.

Other areas of the nation should also be examined, since uranium concentrations above the 10 pc/l level should be quite common in Permian deltaic environments throughout the southwest.

If the proposed limit of 10 pc/l of uranium is adopted and strictly enforced, billions of dollars and years of study will be required to ascertain the cause, effect and possible solutions to dealing with the problem.

The study suggests appropriate management of well placement and re-evaluation of suggested uranium limits as the most appropriate responses to present concern over uranium in the country's drinking water.

Introduction

Ground water resources provide as much as half the nation's vital domestic water supply and are a major factor in the nation's economy. That fact holds true in the greater Oklahoma City area where almost one-third of the state's population resides, and where municipal ground water production averages 40 million gallons daily to supply some 300,000 residents with water. Of a total of 46 municipalities and entities in the region, 12 have no municipal systems, 24 depend solely on ground water and 10 utilize surface water with some conjunctive use of surface and ground water. The towns without municipal systems rely on individual wells for domestic and commercial supply (Canter, et. al. 1979).

There are more than 800 industrial and agricultural wells, in addition to the 250 plus municipal water wells tapping the deep major aquifer, the Garber-Wellington formation. Additional development in the area and the continuing periodic drouths are causing rapid increases in that number.

Surface water sources play a vital role in supplying this region with water, however, that resource alone could not begin to adequately service the 900,000 plus population of the metropolitan area. Therefore, the protection, development and utilization of the Garber-Wellington Aquifer is essential for assuring a continued water supply for the public, industry, agriculture and one of the nation's major air force bases.

General Geologic Setting

Permian strata in central Oklahoma were deposited in a complex series of sublittoral environments ranging from alluvial deltaic fans to tidal flat evaporites.

The Garber-Wellington Aquifer consists of a complex multistoried deltaic series of alternating shales and sandstones commonly referred to as "red beds."

The Anadarko Basin, a large asymmetrical geosyncline west of the Neimeha Ridge (Figure 1) was the major despositional basin which received sediments throughout Pennsylvanian and Permian time contributing to the delta's origin.

As a result of erosion of the Wichita and Arbuckle areas during the Pennsylvanian and Permian periods, Precambrian and Cambrian felsic igneous rocks were exposed and became sources of significant quantities of feldspar in the sandstones and conglomerates.

The Garber and Wellington formations contain lobes of deltaic and interdeltaic sands with associated crossbedding at varied angles. The sandstones are thickest in the Midwest City, Del City and Tinker Air Force Base area and tend to pinch out westward.

Shelton (1979) described the area most comprehensively by describing "units" of disconnected sandstone lenses with a consistent stratigraphic interval. A considerable differentiation in paleocurrent direction was observed and the genetic units were characterized as tidal creek (small scale crossbedding) and stream deposits (those with medium scale crossbedding).

The stream deposits showed a more consistent paleocurrent direction and thus (Shelton) concluded that the source of terrigenous classtics was from streams oriented toward the south and east in the vicinity of the Quachitas (Shelton, 1979).

It has been theorized that these Precambrian feldspathoics are quite possibly a source of uranium anomolies noted throughout Oklahoma. (Al-Shaieb, et. al. 1977)

The Garber sandstone outcrops in a north-south trending bed in eastern Cleveland and Oklahoma Counties with the exposed bedrock formations becoming progressively younger as you move westward. The overall strike of the formation is generally to the north and the formations dip 30 to 35 feet per mile to the west-southwest (Wood & Burton, 1968). (Plates 1 & 2)

Since the Garber-Wellington Aquifer also contains many organic shales and is overlain by the seleniferous Hennessey shale it is also possible that the shales are the main source of uranium in the aquifer. Due to the increased density of feldspathoic clastics in the shales combined with the slow movement of ground water through the aquacludes a mobilization of uranium occurs. This theory seems to hold true since those areas with the least amount of shale also contain little or no uranium.

Research to Date

The Garber-Wellington Research Project is designed to develop protocol for protection, development and management of the nation's ground water supplies. In the process of fully defining the aquifer, all existing information is being assembled with bits and pieces coming from various state and federal agencies as well as cities, towns, industries and individuals. This effort, in conjunction with the development and implementation of a well records-keeping and water quantity and quality monitoring system, has revealed some previously unrealized potential liabilities that exist in this ground water supply.

Specifically, levels of chromium and selenium in excess of the U.S. Environmental Protection Agency's primary drinking water limits exist in a significant number of wells penetrating the aquifer. In addition to these two elements, evidence exists that indicates much of the water produced from the aquifer also contains high concentrations of

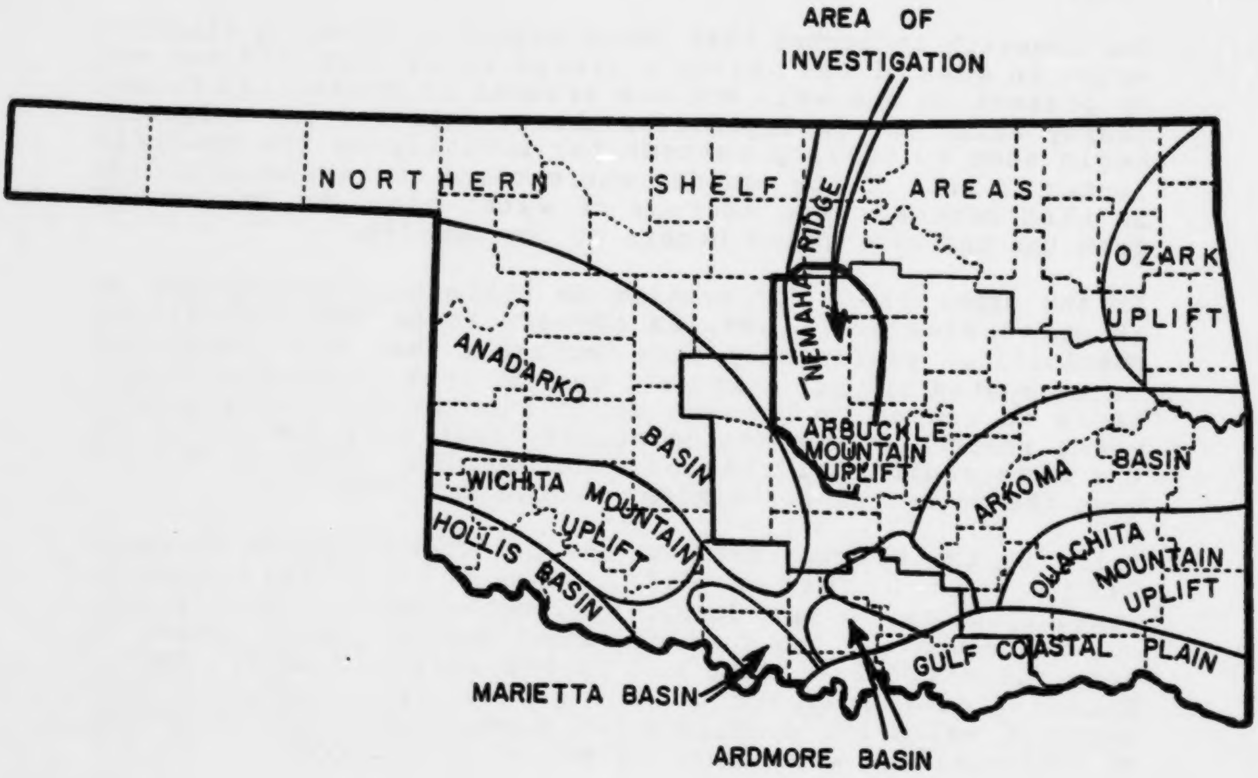
AREA OF INVESTIGATION
NORTHERN SHELF AREAS
NEMAHA RIDGE
OZARK UPLIFT
ANADARKO BASIN
ARBUCKLE MOUNTAIN UPLIFT
ARKOMA BASIN
WICHITA MOUNTAIN UPLIFT
HOLLIS BASIN
OUACHITA MOUNTAIN UPLIFT
GULF COASTAL PLAIN
MARIETTA BASIN
ARDMORE BASIN

FIGURE I Major geologic provinces of Oklahoma

uranium. This is a significant finding, since EPA is in the process of promulgating primary regulations for uranium in drinking water. At this point, EPA's suggested upper maximum limit for uranium is 10 picocuries per liter, a limit that is exceeded locally in some cases by a factor of 10 (OSDH, 1980).

Our research indicates that these naturally occuring elements exist in much of the nation's ground water supplies and may be present in one well but not evident in production from a nearby well. It is imperative that a detailed investigation begin soon to develop methods for identifying the specific lenses or area of the aquifer where these contaminates reside so that contaminated sources of water might be sealed off from the uncontaminated waters of the aquifer.

If the upper limit for uranium is ultimately established at 10 picocuries per liter, as appears to be the most likely possibility, preliminary data indicates that only one ground water system in this area will be less than twice that limit. There is reason to believe at this point that many ground water reservoirs across the country that were formed during the same geological time or under similar conditions will have the potential for similar background radiation.

Prior to the commencement of the Garber-Wellington Research Project in December 1979, the most comprehensive investigations on the Garber-Wellington Aquifer have either not addressed the issue of radionuclides in ground water, or not recognized the issue due to insufficient data. Wood & Burton (1968) analyzed only 3 ground water samples from separate wells and concluded "no signiificant concentrations of radionuclides were found in any of the sources."

Both Carr & Marcher (1977) and Wickersham (1979) reported good to excellent water quality, particularly from the deeper sandstone lenses. Neither, however, analyzed water samples for gross alpha or uranium.

From 1977 through 1980 the Oklahoma State Department of Health's Radiation Protection Division in conjunction with the EPA Environmental laboratory in Montgomery, Alabama began a statewide investigation of radioactivity in Oklahoma's public water supplies. The program was aimed at ensuring the compliance of Oklahoma's ground water with primary drinking water regulations for gross alpha and radium.

Their investigation showed that while all systems currently comply with existing regulations, all but 3 of the 22 public water supply systems in central Oklahoma would not comply with a proposed 10 pc/l standard for uranium (See Table I). It was at this point the Garber-Wellington Association decided a closer look was in order.

TABLE #1

GROUND WATER REPORT ON URANIUM, CHROMIUM AND SELENIUM

Entity	Uranium	Chromium	Selenium
1. Choctaw	*	X	X
2. Del City		X	
3. Edmond	*	*	X
4. Harrah	*	X	
5. Jones	*	X	
6. Luther	*	X	X
7. Midwest City		X	
8. Moore	*	X	*
9. Nichols Hills	*		X
10. Noble	*		
11. Norman		*	*
12. Oklahoma City			
13. Piedmont	*		*
14. Yukon	*		X
Others			
15. Central State Hos.	*	*	X
16. Coyle	*		
17. Deer Creek Water Corp.	*	*	*
18. Independent Water Corp.	*	*	X
19. Lexington Trmt. Center	*		
20. Okla. Univ.	*	*	X
21. Orlando	*		
22. Silverlake, Inc.	*	*	*

X reported to have been detected but in compliance
* reported to have been sampled and above the U.S. EPA Limit

Entities not denoted with an (X) or (*) have not yet been sampled.

This Table was compiled using information from the OSDH and the GWA sampling programs. It is important to understand that while some wells sampled are above the limits, all municipal water systems are meeting the current water quality EPA standards.

While research to date had not concluded the problem even existed, project personnel at the EPA Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma referenced a report completed in 1978 by Union Carbide Corporation, which appeared to show some similarities (Union Carbide NURE, 1978).

The NURE project was directed at sampling approximately 189 Garber-Wellington water wells in the Oklahoma City 1° by 2° quadrangle. All the wells for the most part penetrated the Garber-Wellington Aquifer and had been analyzed for uranium among other constituents. A summary of the report (published in Oklahoma Geology Notes, June 1981 by Bloch et.al.) indicated that only a minute percentage of wells sampled would exceed a uranium standard of 10 pc/l.

Further investigation on the part of the Garber-Wellington Research Project revealed that of the 189 wells sampled, less than 10% were greater than 300 feet deep, and the 19 which exceeded the proposed uranium standard were all in that group. Only 4 wells sampled were greater than 400 feet in depth. Since all of the 250 municipal wells in the metropolitan area are over 300 feet deep and are producing from 500 to 900 feet, it was determined that futher investigation was warranted.

Health Effects

The Garber-Wellington Association staff after contacting the EPA Office of Drinking Water, Health Effects Branch in Washington, D.C., received reports and documents confirming that EPA will indeed attempt to promulgate a primary maximum contaminant level (mcl) for uranium in drinking water during 1982.

Information to date from that office maintains that "knowledge regarding the effects of doses of ionizing radiation requires data concerning the relationship between dose and effect in humans." However, for moral reasons we cannot deliberately expose humans to radiation on an experimental basis. Thus, we have to depend on information from experiments with animals or on epidemiological information for humans exposed to ionizing radiation. There are difficulties and problems with both of these approaches.

The effect of any insult to a human may not be the same as that to animals and vice versa. (Radioactivity in Drinking Water, July 1980). To date no epidemiological study has been performed in central Oklahoma and the scientific basis of the regulation of uranium is highly questionable. Table II summarizes the potential risks to people in the United States from various causes. Note that the potential for dying from consuming water in excess of the uranium mcl is the same as the risk of dying from an insect bite. It is apparent to this author that a continued and indepth research effort to establish a figure based on sound scientific fact rather than conjecture would be considerably more justified than forcing economically unsound regulations on the already water short southwest.

Table II Risks to people in the United States from various causes

CAUSE	DEATHS/MILLION PEOPLE EXPOSED (IN 1977)
All Cardiovascular Disease	4700
Cancer	1750
Major Cardiovascular Disease	880
Automobile	230
Home Accidents	150
Falls	65
Air Pollution from Fossil Fuel Power Plants	50
Fire/Burns	30
Drowning	30
Melanoma (Skin Cancer thought to be due to ultraviolet Radiation from the sun) (15)	26
Poison	25
Cancer Deaths from Natural Radiation (100 mrem/yr)	20
Cancer Deaths Due to Medical X-Rays	16
Firearms	9
Air Travel	7
Electrocution	6
Cancer Deaths from Exposure to 5 mrem/yr (EPA Standard for Drinking Water)	1
Animal & Insect Bites	1
Lightning	0.5
Tornados/Hurricanes	0.4

(From Cothern, 1981)

Other Occurrences Nationally

"Uranium is present in trace or minor amounts in all ground water. The solubility of many uranium compounds in water is high enough to suggest that several parts per million (ppm) could occur in solution. Actual amounts found generally vary from 0.05 to 10.0 parts per billion" (Davis and De Wiest).

1.5 ppb is roughly equivicable to 10 pc/l for uranium. It appears that EPA feels strongly enough about its 10 pc/l mcl that it wishes to force a number of the potable ground water supplies nationwide to come up with alternative supplies or treatment facilities.

Continuing investigations in other areas of the country continue to document the widespread national occurrence of radionuclides in ground water, yet little or no information has been disseminated documenting health risks.

Cartwright (1978) performed an extensive investigation of municipal water supplies in Illinois and combined that with soil analyses. "Analyses of water from municipal wells in Illinois by the Illinois EPA showed that more than 300 wells exceeded the upper limit of gross alpha (15 pc/l) radiation in drinking water." The study went on to state that the natural occurrence of uranium 238 was the obvious source and that the nature of the geology indicated the problem was not limited to just Illinois.

"Analyses of a limited number of rock samples indicated that uranium and thorium concentrations were highest in fine grained sediments in the aquifer systems; the highest concentration was in shales that confine the aquifer" (Cartwright, 1978).

Several other areas of the United States have already identified concentrations of uranium in ground water well above the proposed 10 pc/l mcl. Some cases in point are:

Research in Colorado by the Las Alamos Scientific Laboratory documents ground water samples from wells in the Lamar NTMS quadrangle are well above the proposed 10 pc/l standard. "The mean uranium content of well water samples is 19.42ppb; water samples from 21 wells contain more than 100ppb uranium" (Shannon, S.S.Jr., 1979).

The report concluded the source of uranium to be the Pierre shale and associated underlying members.

Shelton, 1977 deduced through intensive investigations that radioacative anomolies occur throughout southeastern Oklahoma and are positively associated with feldpars and shales. The highest concentration of uranium was from a well near Cement, Oklahoma and contained 120ppb uranium.

As before, samples were associated with organic shales.

Common occurences in the Colorado plateau are in the vicinity of 15ppb, and 90ppb cases have been reported in the Soviet Union. A Canadian publication recently reported that more than one third of the wells tested near Halifax, Nova Scotia show high levels of uranium. Of 299 wells tested, 101 exceeded 15 pc/l (the Canadian standard for uranium).

In central Oklahoma approximately 50% of the 200 municipal wells sampled showed that they could not meet the 10 pc/l mcl. Even if the proposed mcl were raised to 50, there would still be approximately 15% of wells still out of compliance. How mixing of water could possibly be achieved in the distribution system to maintain compliance has not yet been determined.

The main conclusion to be drawn from these examples is that ground water moving through concentrated uranium rich sandstone or highly organic shales generally has more than 20ppb and often as high as 200ppb uranium.

Alternatives

Radioactivity in drinking water (EPA, January 1981) lists the following control techniques for radioactivity in ground water:

1). "A new well may be drilled, and used by itself, or its water may be blended with more radioactive water to reduce the concentration."
2). "Bottled water may be used to replace water with high radioactivity."
3). "The primary technological methods available for reducing the concentrations of radioactivity are ion exchange, lime softening and reverse osmosis."

Each of these shall be discussed in some detail but the first thing to realize is that central Oklahoma currently has 22 separate water systems and all but 3 utilize only ground water without treatment.

The first alternative of drilling a new well assumes that you can locate a source of lower uranium concentration in an area you already know is well above the proposed limit! A considerable amount of time and money could be easily expended by haphazardly drilling wells without indepth geologic investigations.

Two examples of specialized test hole drilling have currently been researched, and will be discussed later.

Some new innovative techniques are currently being examined for determining how to locate areas of contaminated water and examination of various layers within the aquifer for zones containing lower concentrations of uranium.

The first of these techniques is performed by running a spectralog™ in a pilot hole prior to expansion of the hole into a production well. The spectralog™ is a technique which has previously been utilized only in minerals exploration at very great depths. Thus, some adaptations would be necessary before full scale efficient utilization would be cost effective in water well investigations.

Figure 2 is an example of an actual log run. While the procedure gives an excellent analysis of the amount of potassium, uranium and thorium contained in the formation, it is almost impossible to deduce from the log what the uranium content of the produced formation water will be.

The information from this research has shown a positive correlation between the uranium content and the shale layers within the formation.

While this particular log shows an average formation concentration of uranium of 145 ppm of uranium, the actual formation water, sampled at a later date, contained 65 pc/l uranium. Additional samples are scheduled for analysis to track possible increases or decreases over prolonged usage.

At another test site, the suggested perforation intervals were decreased to effectively limit the amount of water which would be dewatered from the shale layers. This technique was also ineffective in that no decrease in concentrations were observed.

Current research is pursuing investigations regarding computer mapping procedures for possible well spacings, based on computer generated maps of extrapolated uranium concentrations based on known data. (Figure 3)

This technique has not yet been field tested due to the expense involved in drilling a series of test holes to document actual concentrations.

Depending on future funds available for this type of research, this alternative along with packer pump testing of individual strata remain to be evaluated as possible solutions to continued efficient ground water production.

The second alternative suggested by EPA is too ridiculous to even consider, since the cost of providing bottled water to 400,000 residents can't even be comprehended, much less considered economically feasible.

The third alternative, which involves the treatment of the water supplies, appears to be the only available alternative. Since there are no additional surface water supplies which can be developed in this area, non-treatment of our ground water would all but eliminate effective use of ground water in this region.

FIGURE 2

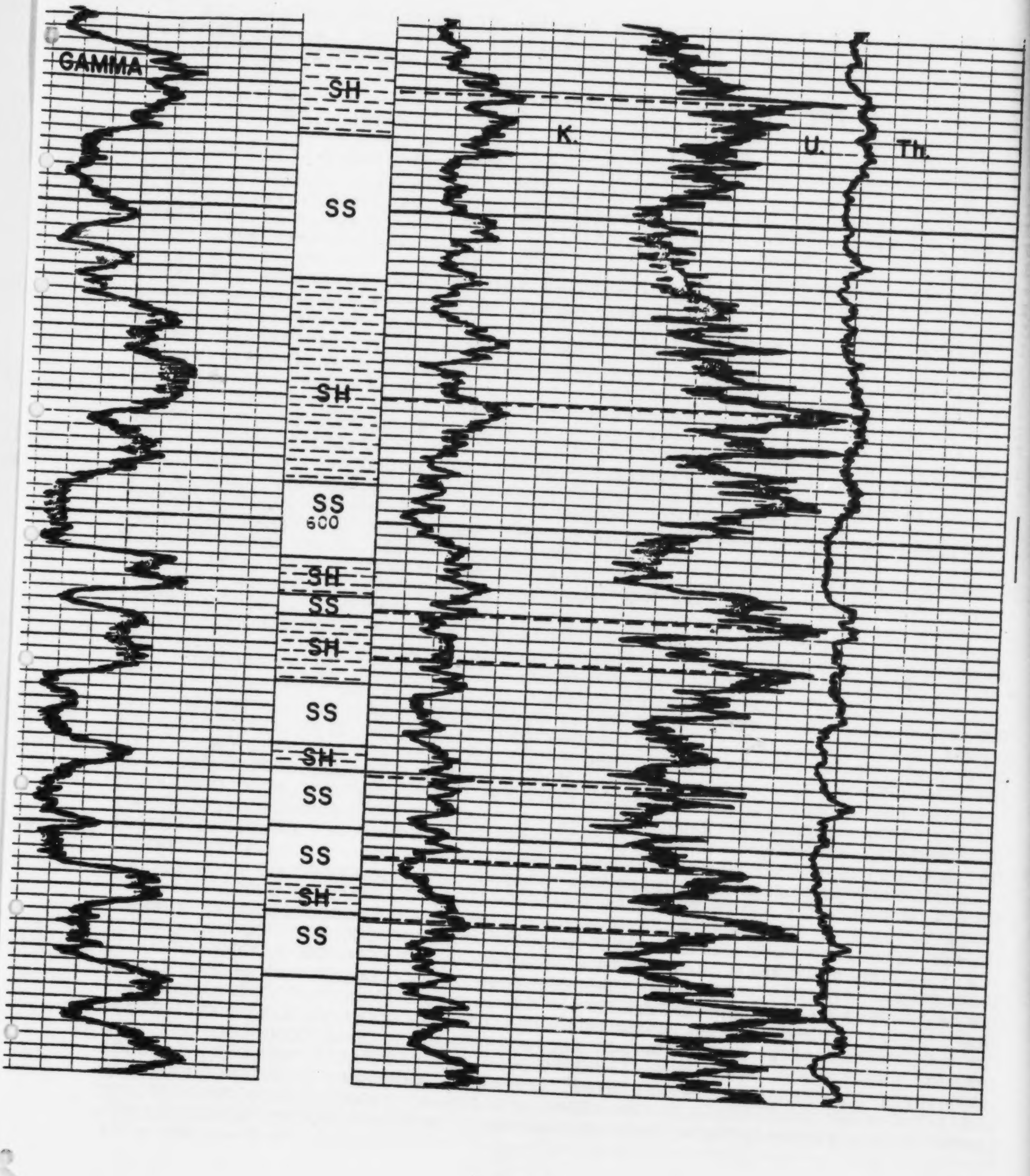

FIGURE 3 This map represents a computer generated contour map of theorized uranium concentrations in one Township and Range, given eight data points. Contours are in 15 pc/l intervals.

KEY		
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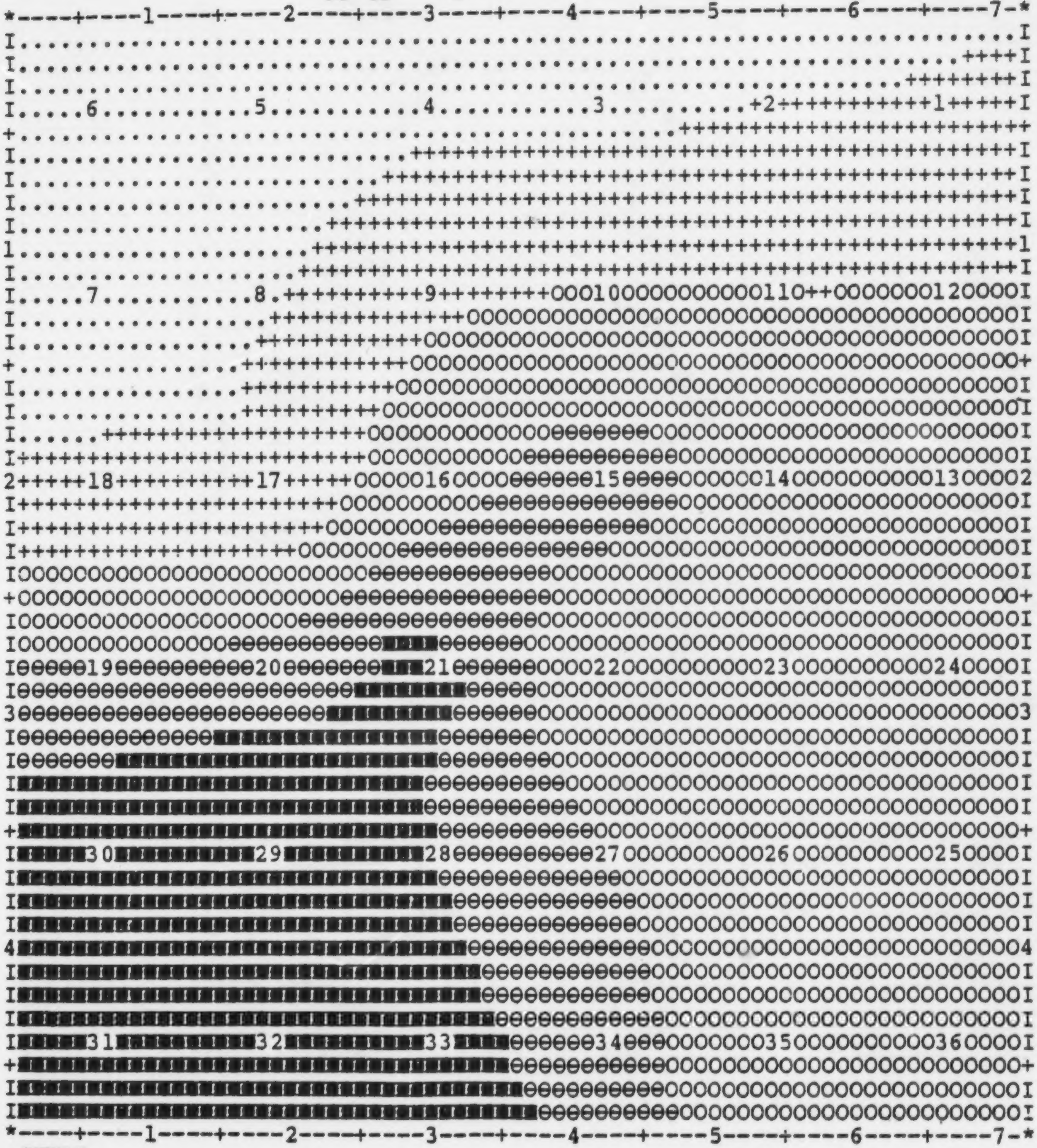
	15-30	+
	30-45	0
	45-60	θ
	60-75	■



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SYMAP

The three methods given for treatment of uranium in drinking water are the same as that prescribed for the removal of radioactive contaminants in the "Manual of Treatment Techniques for Meeting the Interim Primary Drinking Water Regulations" (EPA, 1977). Of these three treatment processes "reverse osmisis is the most expensive process, although it is the most suitable for automated plant operation and use in small plants. Ion exchange, which is generally used in a batch process, is estimated to be the least costly. Lime softening has most frequently been the process of choice for large treatment plants" (EPA, 1977).

The associated costs with such procedures assumed 50 pc/l entering water and 80% removal efficiency. Figures 4 and 5 summarize the efficiency of current removal techniques. From these 2 examples, it appears that no matter which alternative is selected, capital costs for a plant capable of serving the greater Oklahoma City area would run in the vicinity of 10 billion dollars. The resulting cost of treatment per thousand gallons of water would approach 1 dollar as compared to less than the .05 cents currently.

The cost of 19 separate treatment facilities would be astronomical, since the well systems currently pump directly into a distribution system and would require some type of a main line installation to provide water to a central treatment facility prior to distribution.

Assuming this could be accomplished, the cost of the treated water would be prohibitively expensive for all industrial and most residential customers.

The problem also remains regarding the safe disposal of low-level uranium residue collected from the treatment facility. If EPA feels that levels above 10 pc/l are unsafe, certainly a concentration collected from many sources by mandating treatment would be well above the limit. This would then involve special handling costs, safe disposal costs and access to a disposal site, since none currently exist in central Oklahoma.

Since it appears that the promulgation of a uranium standard is also intended to apply to municipal dischargers, leaving the water untreated also poses a problem for wastewater treatment facilities. (See Federal Register Vol. 46, No. 6)

If the uranium standard is established only for dischargers of effluent and not for public water supply, the end result is similar, since the uranium ends up at municipal wastewater treatment facilities.

Forcing such a procedure on an already water short area seems counter-productive to current federal efforts to reduce the costs associated with providing basic governmental services.

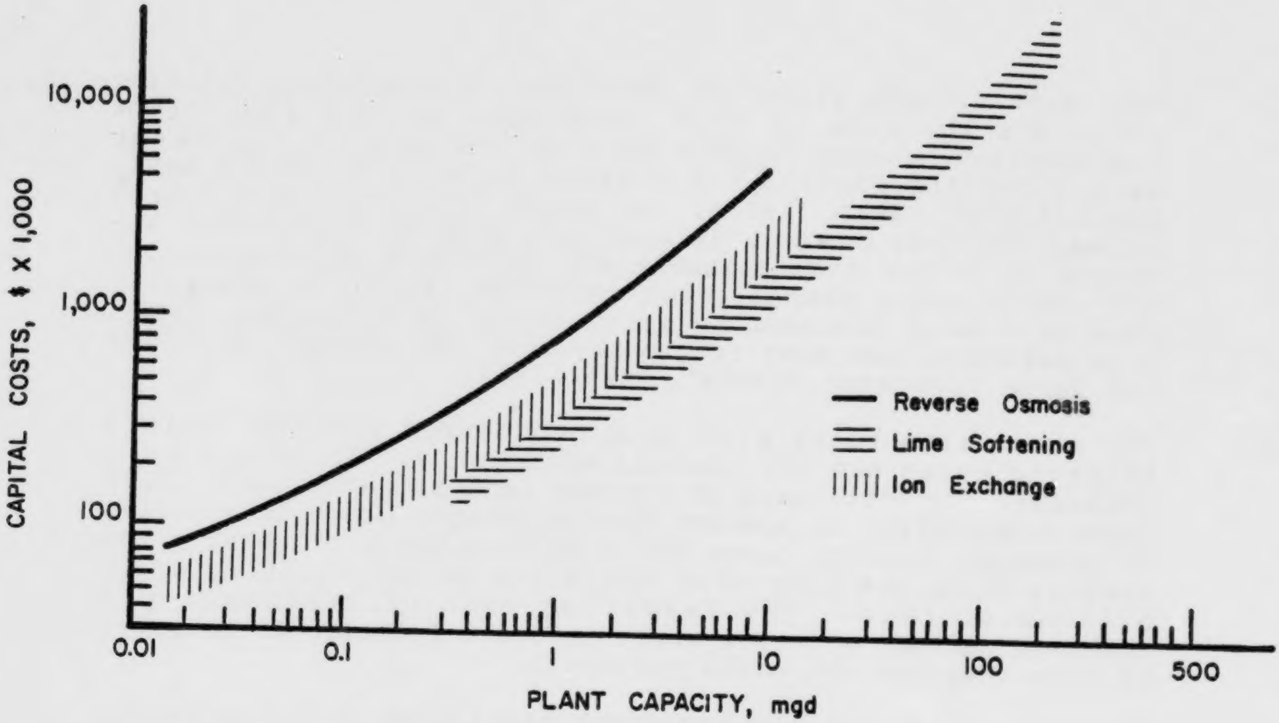

FIGURE 4 CAPITAL COST FOR WATER TREATMENT PLANTS FOR 50 pCi/l IN RAW WATER

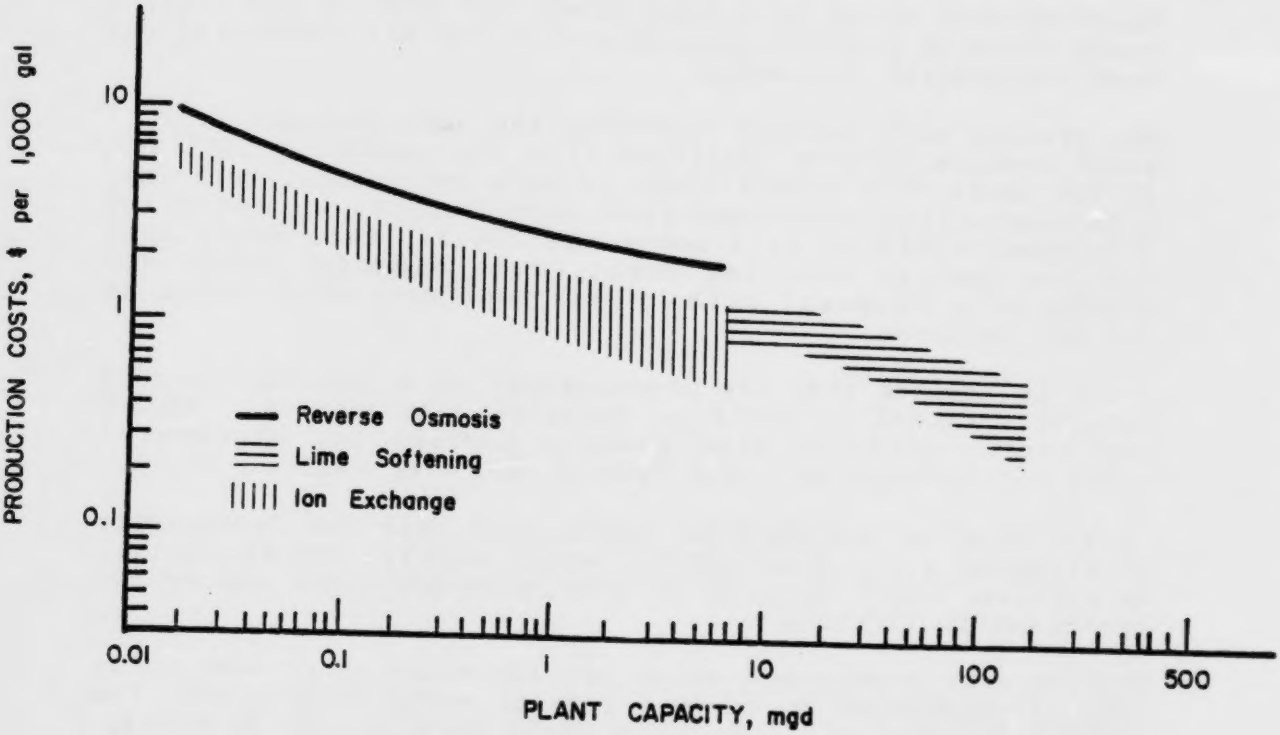

FIGURE 5 ANNUAL PRODUCTION COSTS (OPERATION MAINTENANCE, AMORTIZATION) FOR 50 pCi/l IN RAW WATER

Acknowledgment

This research was funded through a grant from the Environmental Protection Agency's Ground Water Research Branch and the Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma. The author would like to thank the following persons for their valuable information:

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PLATE I

GEOLOGIC FEATURES

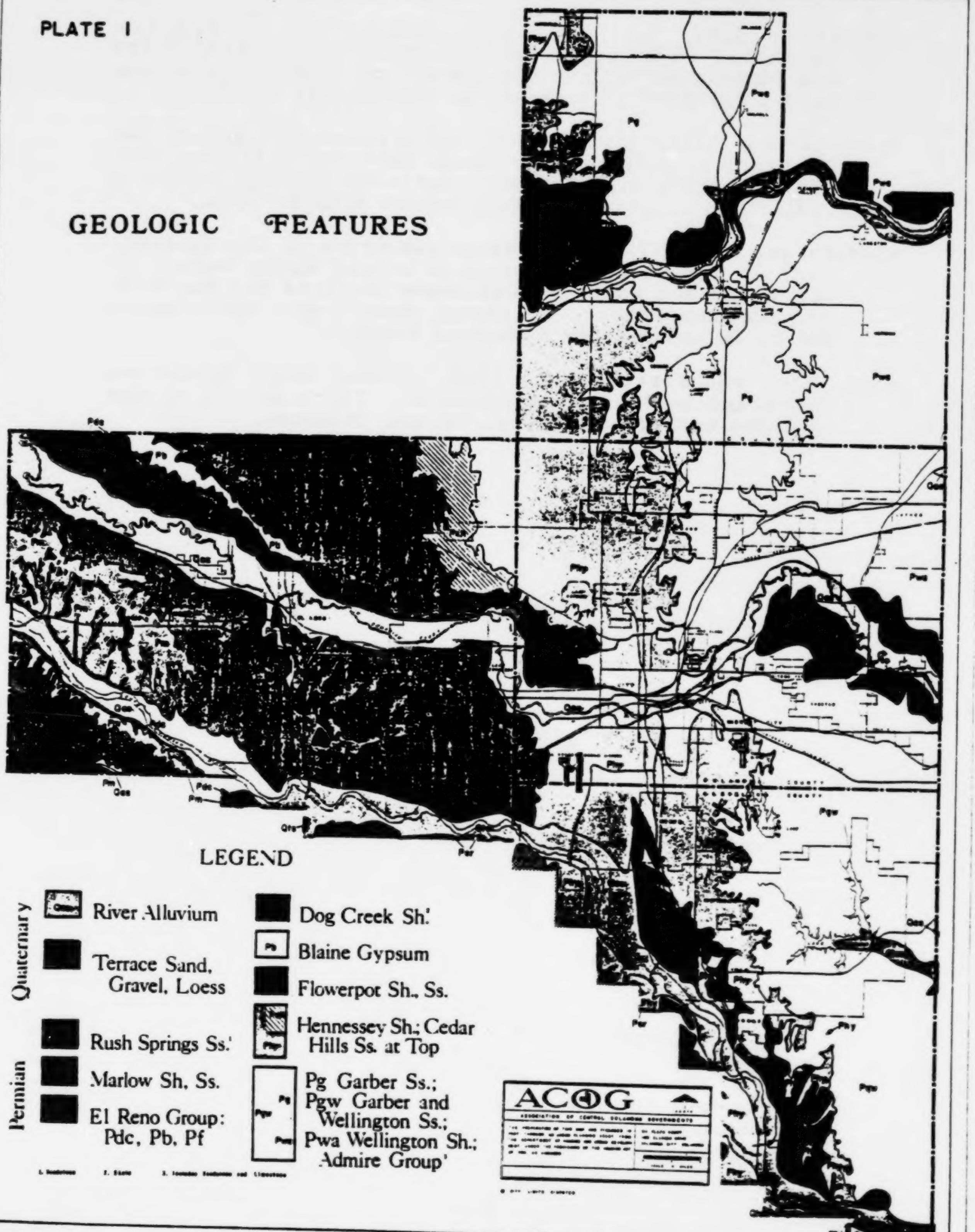
LEGEND
Quaternary
Qas River Alluvium
Terrace Sand, Gravel, Loess
Permian
Rush Springs Ss.
Marlow Sh. Ss.
El Reno Group: Pdc, Pb, Pf
Dog Creek Sh.
Pb Blaine Gypsum
Flowerpot Sh., Ss.
Hennessey Sh.; Cedar Hills Ss. at Top
Pg Garber Ss.;
Pgw Garber and Wellington Ss.;
Pwa Wellington Sh.; Admire Group
ACOG
ASSOCIATION OF CENTRAL OKLAHOMA GOVERNMENTS
Pg
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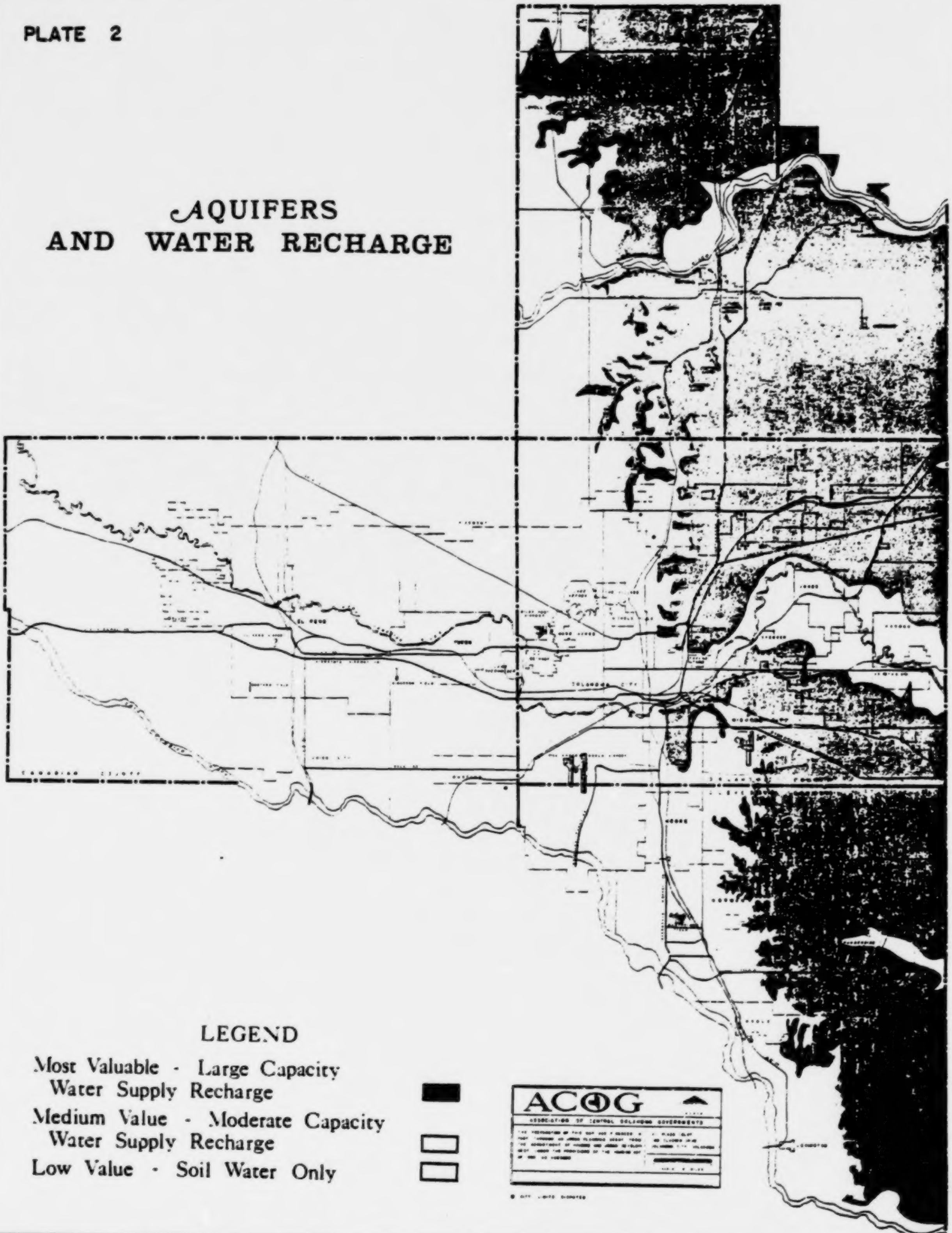
PLATE 2

AQUIFERS AND WATER RECHARGE



LEGEND

Most Valuable - Large Capacity Water Supply Recharge ■

Medium Value - Moderate Capacity Water Supply Recharge ☐

Low Value - Soil Water Only ☐

Appendix VI

Preliminary Estimate of Effective Ground-Water Recharge Rates in Central Oklahoma

ABSTRACT

Ground-water recharge rates for the unconfined part of the Garber-Wellington Aquifer in central Oklahoma were estimated for water years 1973, 1976, 1978, and 1979 by means of a computerized stream hydrograph separation technique. Although many factors influence recharge rates, it would appear that, on the average, about 100,000 gallons per day per square mile, or about 2.11 inches, of water infiltrates the aquifer and then finds its way to a nearby stream.

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INTRODUCTION

The Oklahoma Water Resources Board is investigating the Garber-Wellington Aquifer system, which is the major source of water supply for municipalities and industries in central Oklahoma. This report is a small part of the overall project, and its purpose is to estimate the rate at which precipitation infiltrates and reaches the water table (ground-water recharge rate) in the unconfined part of the aquifer. The analysis is based on a computer program that separates stream flow into its two major components--surface runoff and ground-water runoff.

GENERAL FEATURES OF THE AREA

The study area, which includes the outcropping rocks of the Garber-Wellington Aquifer, lies in central Oklahoma between 96° and 98° longitude (Plate 1).* The region is characterized by a gently eastward sloping surface of rolling, grass-covered prairie and low, wooded hills. It includes about 23,000 square miles, although the drainage area is considerably larger.

Annual precipitation in Oklahoma ranges from more than 56 inches in the southeast to less than 14 inches in the western part of the panhandle (Fig. 1). The average annual precipitation rate is about 32 inches. The greatest amount of precipitation generally occurs in May while January is typically the driest month.

Although Oklahoma is subhumid, annual lake evaporation ranges from about 46 inches in the northeast to more than 56 inches in the northwest

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*Plate 1 is enclosed in the envelope at the end of this report.

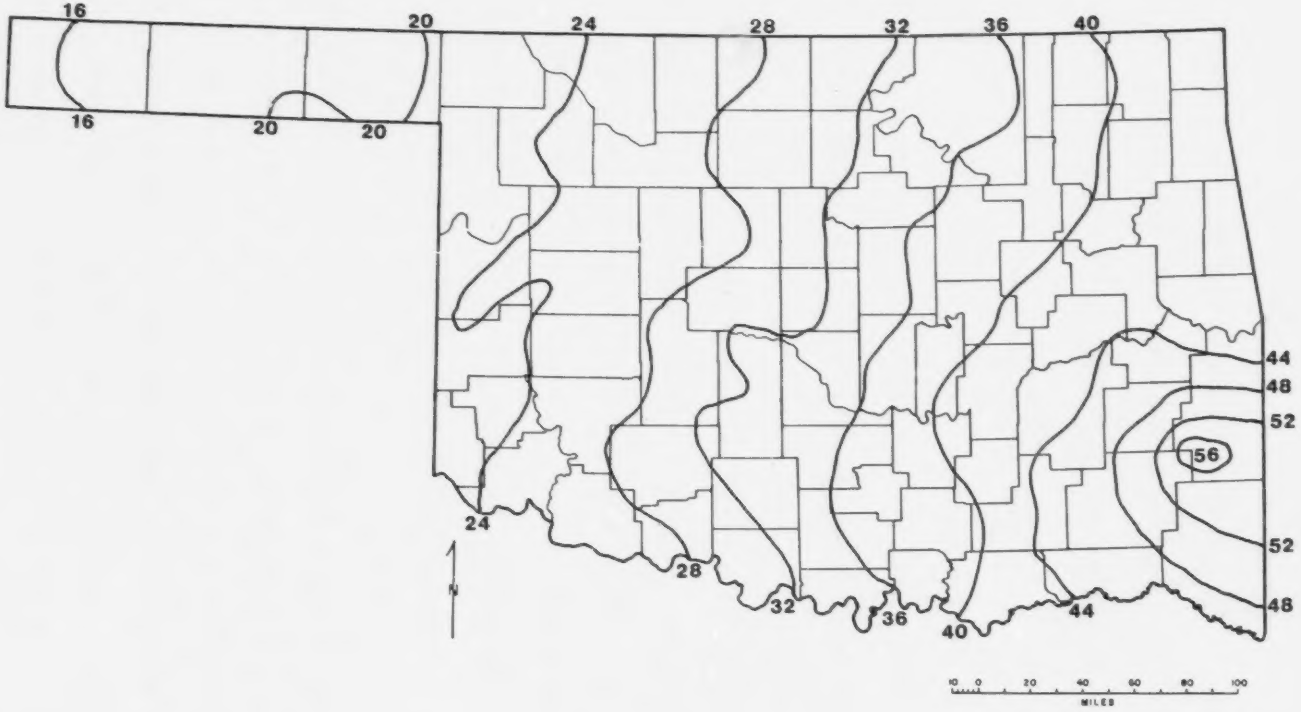
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Figure 1. Average annual precipitation in Oklahoma, in inches for the period 1931-1960 (Modified from Oklahoma Water Resources Atlas, 1976).

(Fig. 2). Since evaporation exceeds precipitation throughout most of the state, much of the time there is a soil-moisture deficiency and groundwater recharge is not great.

Average annual runoff in Oklahoma ranges from less than 0.2 inches in the panhandle to more than 20 inches in the extreme southeast (Fig. 3). Runoff is closely related to precipitation and evapotranspiration.

GEOLOGY OF THE AREA

In central Oklahoma, bedrock dips 30 to 40 feet per mile westward toward the Anadarko Basin. Cropping out through much of this area (Plate 1) is the Garber-Wellington Aquifer, which consists of about 900 feet of interbedded sandstone, siltstone, and shale representing delta deposits. The Garber-Wellington is Early Permian in age.

The sediments were deposited by westerly flowing streams which had their major axis at about the same latitude as Oklahoma City. As a result, the ratio of sandstone to shale reportedly decreases both northward and southward from this area. Furthermore, there is also a downdip or westward decrease in grain size from predominantly sandstone to predominantly shale.

The aquifer consists of channel sandstone deposits that are interfingered with shale units. Due to the nature of the deposits, abrupt changes in lithology are common. The maximum thickness of any one sandstone unit is about 40 feet, but they generally range between 5 and 10 feet. Shale layers, which average about 5 feet in thickness, have a maximum thickness of about 50 feet. Sandstone makes up about half of the aquifer, although this lithology ranges from about 30 to 75 percent of the total unit. The maximum amount of sandstone relative to shale is in the vicinity of Oklahoma City. The sandstone is typically fine-grained,

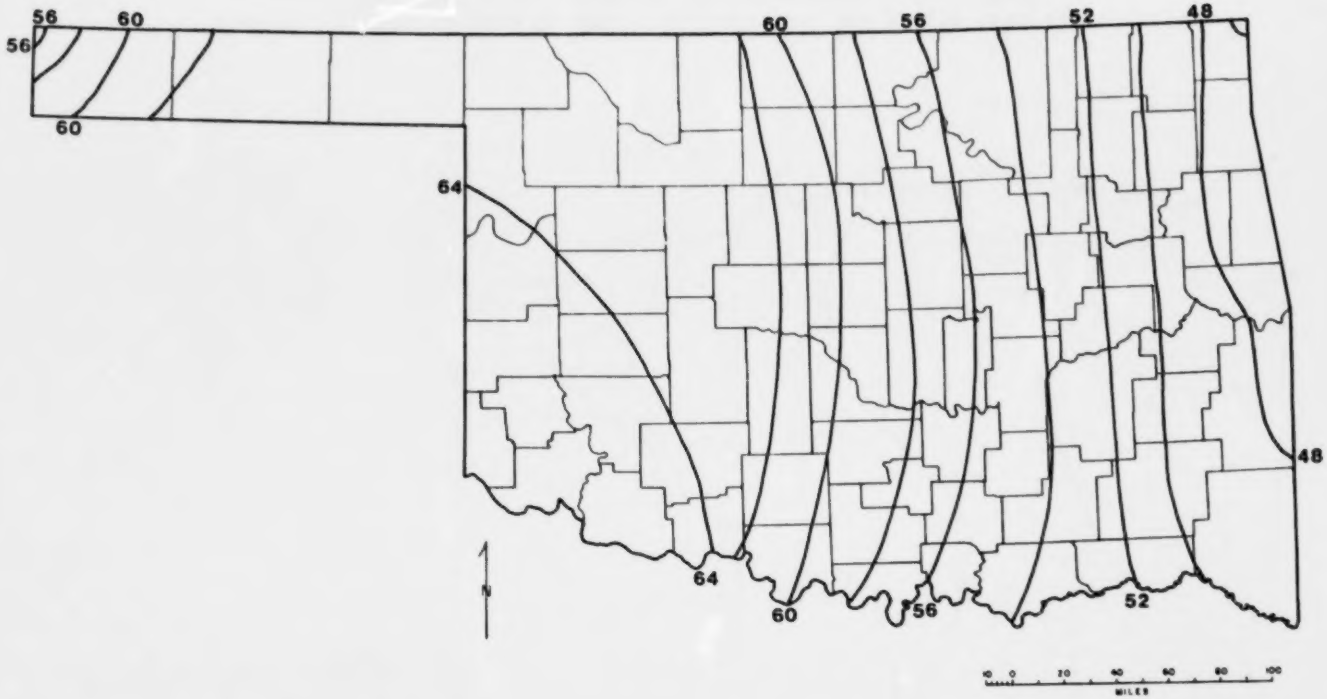
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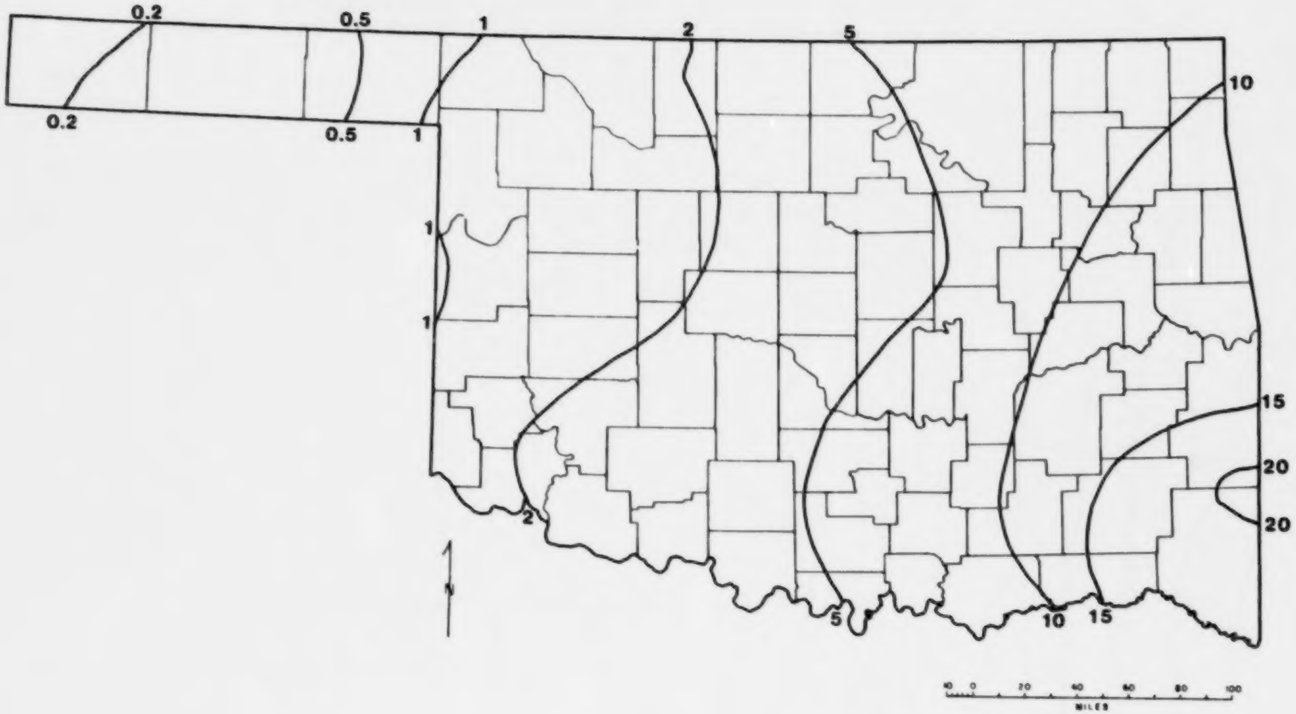
Figure 2. Average annual lake evaporation, in inches for the period 1946-1955 (Modified from Oklahoma Water Resources Atlas, 1976).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MILES

Figure 3. Average annual runoff, in inches for the period 1931-1960 (Modified from Oklahoma WaterResources Atlas, 1976).

crossbedded, and reddish brown (see Fig's. 4-17). Locally, zones of muddy conglomerates and coarse-grained sand are present.

In the western part of the study area the Garber-Wellington is confined and is covered by the Hennessey Group, which is also Early Permian in age. In these areas recharge must find its way through the shale, migrate downdip, or leak from adjacent units. The Hennessey Group consists largely of shale and siltstone, with some thin layer of very fine-grained sandstone. In some areas both the Garber-Wellington and Hennessey Group are overlain by alluvium and terrace deposits. In general, streams fed by discharge from the Garber-Wellington are perennial, whereas streams draining the Hennessey Group flow only during and a short while after precipitation.

The Garber Sandstone and Wellington Formation have similar water-bearing properties, are hydrologically interconnected, and are considered as a single aquifer. Water-table conditions exist in many places in outcrop areas and, reportedly, in the upper 20 feet of the aquifer. At depths greater than 200 feet and beneath the Hennessey Group, the aquifer is semiconfined or confined. Transmissivity values obtained from aquifer tests range from 3,000 to 7,000 gallons per day per foot, while specific capacities average about 1.3 gallons per minute per foot of drawdown. Well yields, which range from 70 to 475 gallons per minute, average 245.

The deeper parts of the Garber-Wellington Aquifer contain water with a dissolved solids concentration in excess of 1,000 mg/l. Hardness is greatest in the upper parts of the aquifer, and the concentration of sulfate, chloride, and dissolved solids increases with depth. Overall, the quality of the water is considered good for an area of limited rainfall.

Floodplain deposits exert a major influence on stream flow in the region. These deposits are commonly sand, several to several tens of

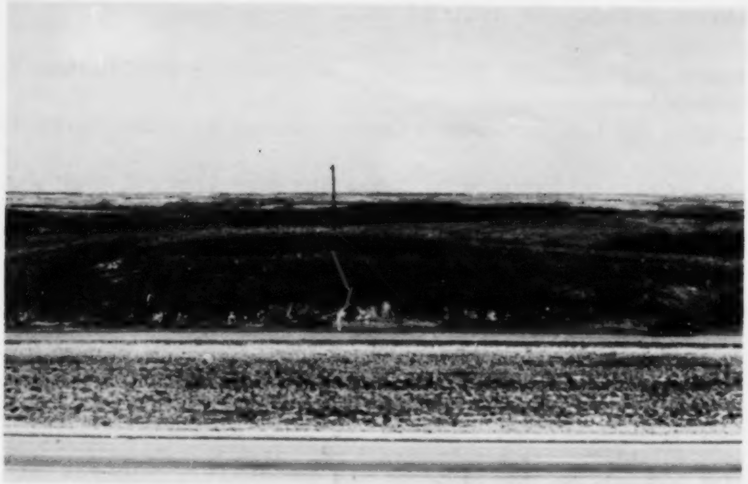

Figure 4. Red to dark brown sandstone interbedded with shale, which is typical of the Garber-Wellington Formation. The background topography is common in the study area.

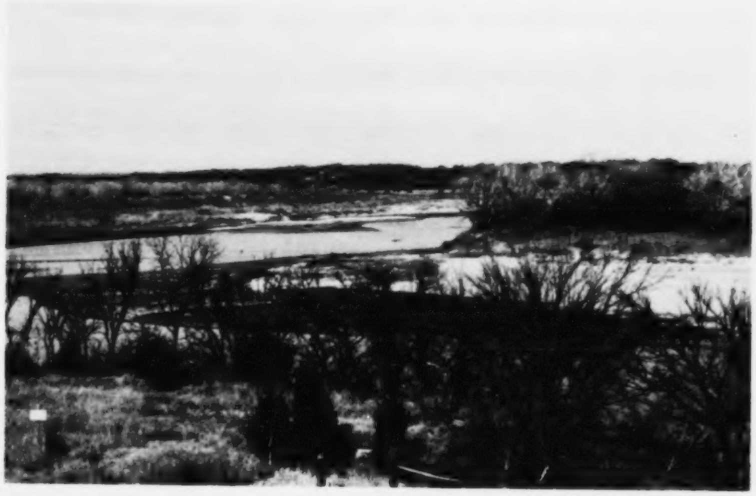

Figure 5. Cimarron River at I-35. Alluvial deposits and rolling topography of study area.

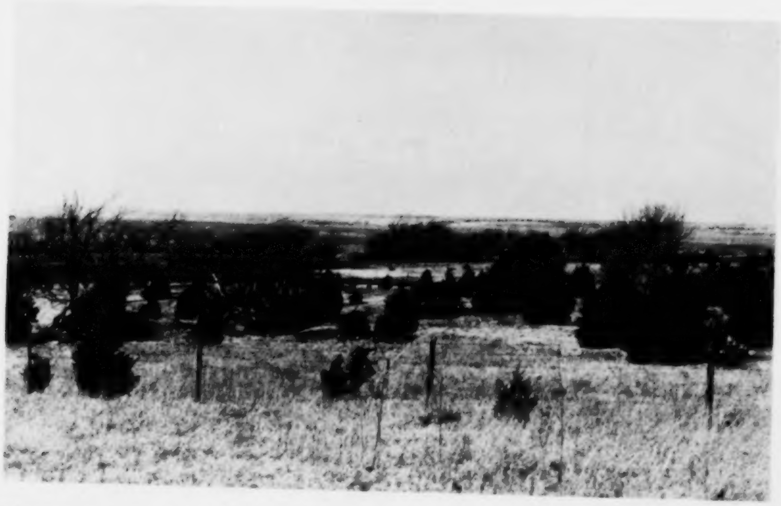

Figure 6. Typical topography of areas underlain by Garber Sandstone near Guthrie.

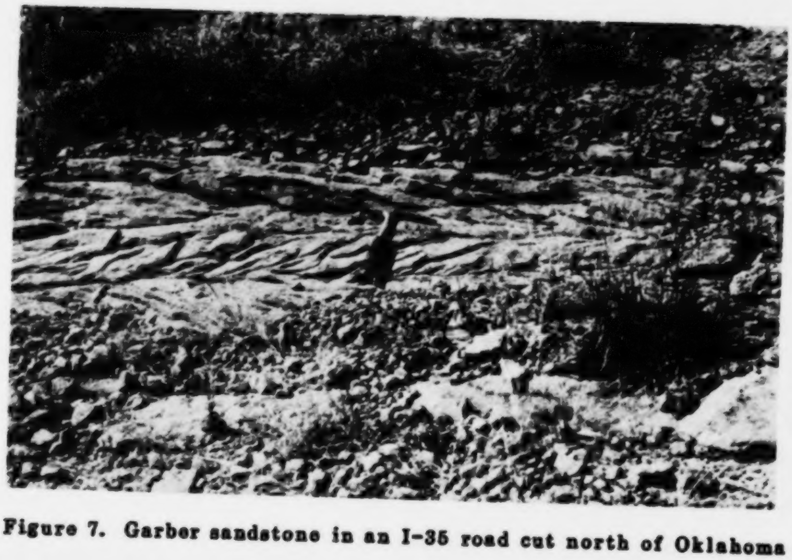

Figure 7. Garber sandstone in an I-35 road cut north of Oklahoma City.

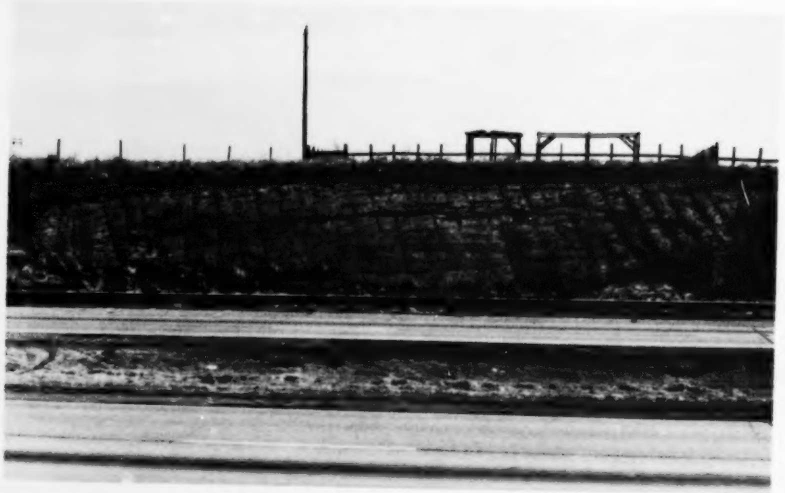

Figure 8. Massive lenses of Garber sandstone in a road cut near I-35 north of Oklahoma City.

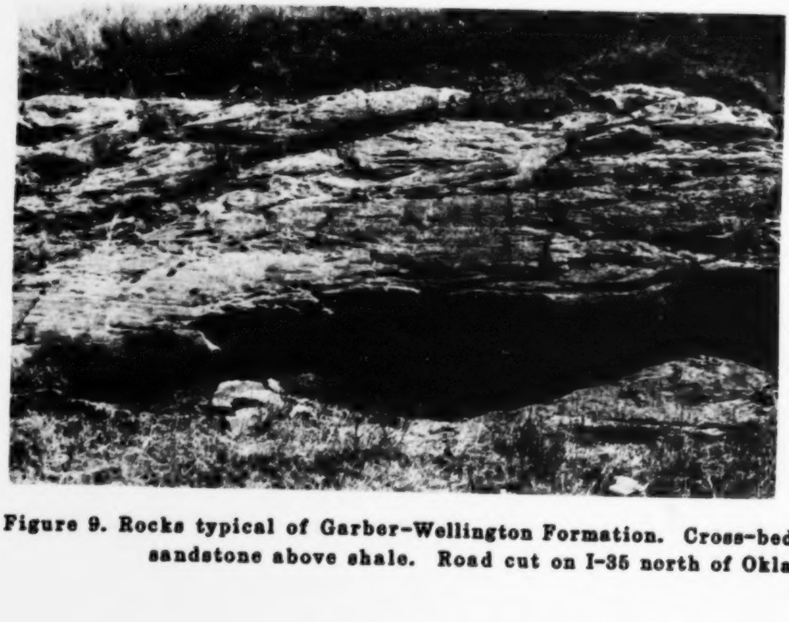

Figure 9. Rocks typical of Garber-Wellington Formation. Cross-bedded sandstone above shale. Road cut on I-35 north of Oklahoma City.

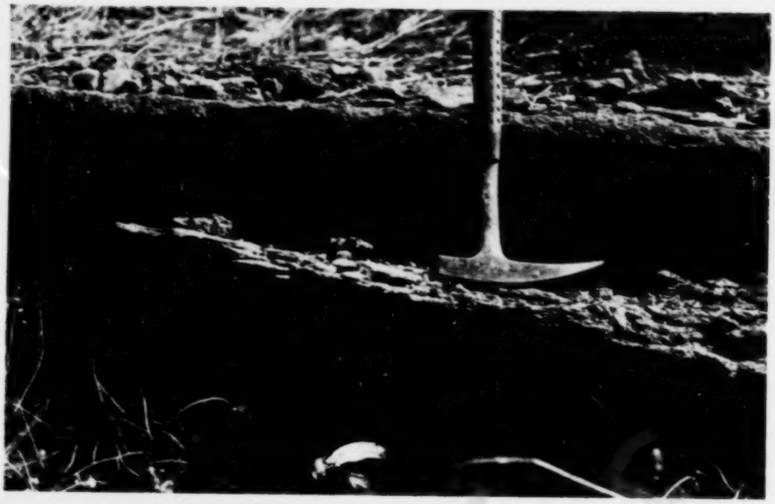

Figure 10. Interbedded sandstone and shale of the Garber-Wellington Formation. Road cut north of Oklahoma City on I-35.

Figure 11. Stream northeast of Oklahoma City cutting through colluvium on top of the Garber-Wellington.

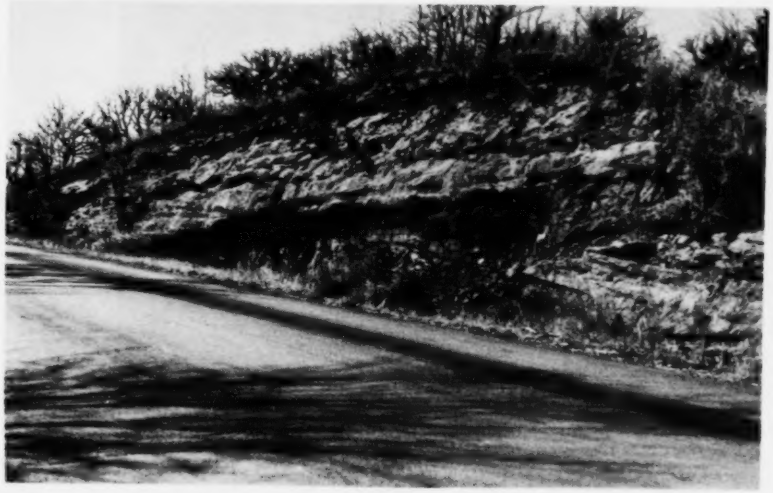

Figure 12. Road cut northeast of Oklahoma City. Cross-bedded sandstone with associated shale of the Garber-Wellington Formation.

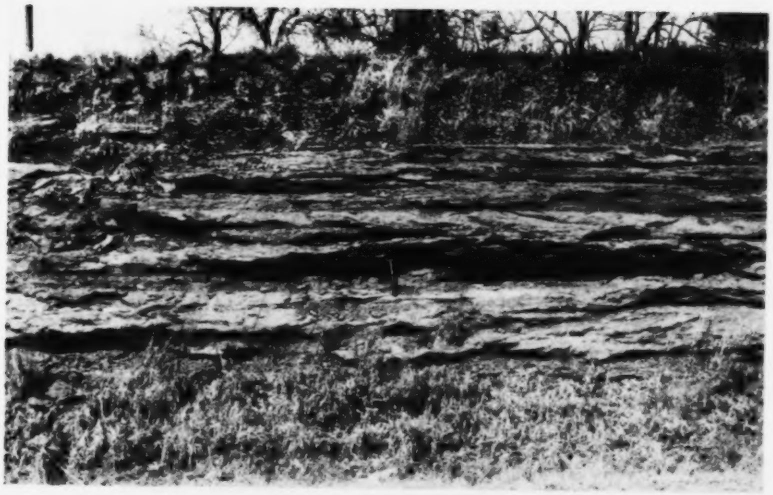

Figure 13. Interbedded fine sandstone and shale of the Garber-Wellington in a road cut northeast of Oklahoma City.

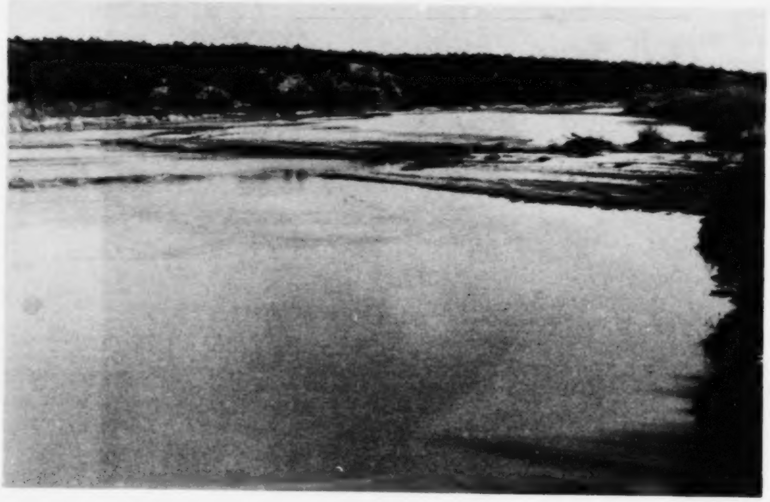

Figure 14. Cimarron River at the Payne-Logan County line. Wide alluvial deposits of fine sand.

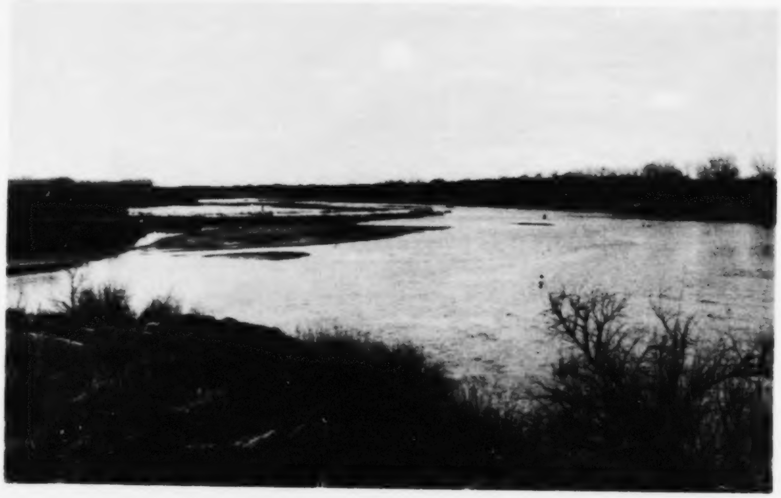

Figure 15. Cimarron River at the Payne-Logan County line. Wide alluvial deposits of fine sand.

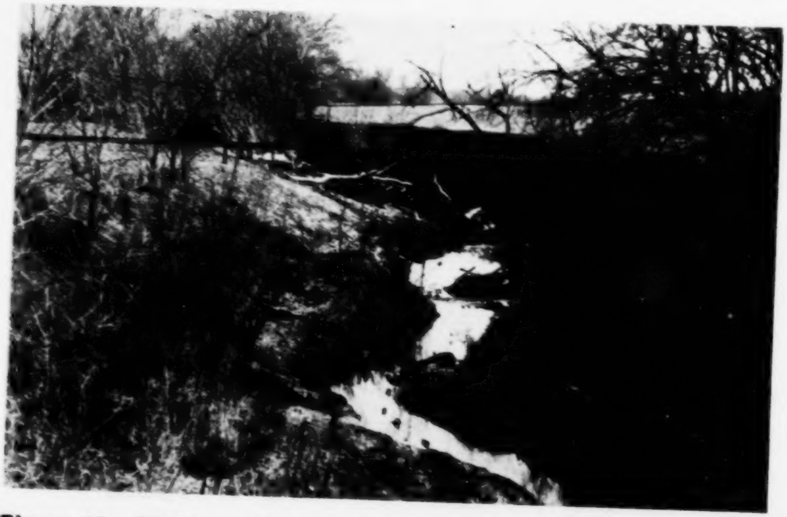

Figure 16. Wildhorse Creek at Highway 33 where it cuts through colluvium that overlies the Garber-Wellington.

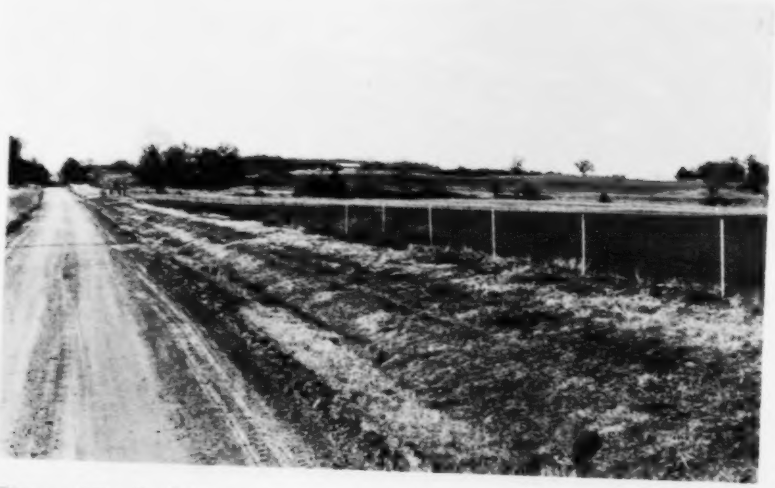

Figure 17. Perkins Terrace, one mile west of Perkins. Sand dunes consisting of fine, permeable sand overlying the Garber-Wellington.

feet thick, and highly variable in width and length (Plate 1). In many areas, the floodplain deposits are hydrologically connected to adjacent sand dunes and form an extensive, permeable hydrologic system. In these areas there is likely to be but little surface runoff since most of the precipitation quickly infiltrates.

Alluvial deposits influence stream discharge for two major reasons. First, they are major recharge areas. Secondly, they tend to damp river stage fluctuations since part of the stream flow during periods of rising stage infiltrate the banks and temporarily remain there as bank storage until the stage falls.

METHODS OF INVESTIGATION

This preliminary estimate of natural recharge to the Garber-Wellington Aquifer is based on the assumption that the precipitation that infiltrates and reaches the water table in the zone of intensive circulation eventually discharges to streams. It is this ground-water runoff that causes a stream to flow during dry periods. A much larger percentage of precipitation that infiltrates is taken up as soil moisture and eventually returns to the atmosphere by evaporation and transpiration. A very small amount of water that reaches the water table is withdrawn by wells; this component is not considered in this analysis because it is minute when compared to ground-water runoff.

In order to determine effective ground-water recharge rates, it is necessary to separate a stream hydrograph into surface runoff and ground-water runoff. This is accomplished by a method developed and described by Pettyjohn and Henning (1979). Ground-water runoff is assumed to equal effective ground-water recharge.

This particular technique was used successfully in a study that included the entire state of Ohio. It has been used elsewhere also, but not in a region that is hydrologically similar to Oklahoma. Presumably the technique is transferable, but it has not been proven by other methods. For this reason the natural recharge rates described herein must be used carefully.

The effective recharge rates described herein were determined by three different methods: the sliding method, fixed-interval method, and local minimum. Generally two of the three methods provide results that are in close agreement, while the third may differ considerably. This is due to differences in the hydrology of the basin, particularly the effect of streamside deposits. Where these contain permeable materials and influence bank storage, as is generally the case in central Oklahoma, the sliding and fixed-interval methods provide the most comparable results.

The long-term precipitation pattern also has an effect on stream flow and ground-water runoff. For example, if there has been two or three years of below normal precipitation followed by a wet year, as in the case of water year 1973, the calculated recharge rates will be lower than a wet year that has been preceded by two or three years of normal precipitation. The opposite is also true. This effect is related to replacement of both soil moisture and ground-water storage. Because of variable climate situations, recharge rates will also vary from one year to the next.

INVESTIGATIVE RESULTS

Precipitation data from stations at Enid, Okemah, and Pauls Valley (Fig. 18) were examined for the years 1973, 1976, 1978, and 1979. Except for 1979, these years were suggested by the Oklahoma Water Resources Board as being indicative of wet, dry, and normal years of precipitation. As

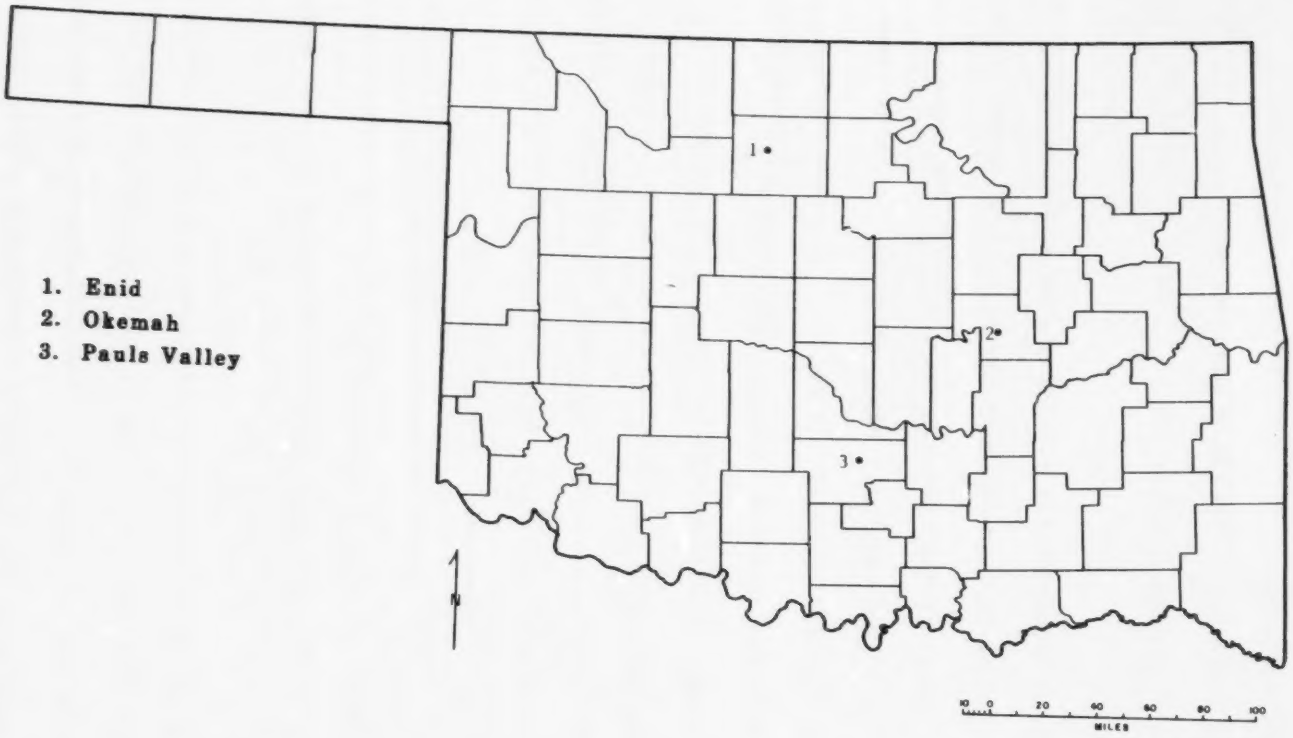
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Figure 18. Precipitation stations used in the recharge investigation.

shown in Fig's. 19, 20, and 21, 1973 was above normal and 1976 was unusually dry, but 1978, rather than being normal at these three stations, was only slightly wetter or dryer than 1976, as far as average annual precipitation is concerned. For these reasons, water year 1979 was examined. Monthly precipitation of these stations is shown in Fig's. 22, 23, and 24.

A soils map of Oklahoma was greatly generalized in order to focus more clearly on areas that should have higher natural rates of recharge (Fig. 25). The category with the highest potential for natural recharge contains sandy soils and generally sandy subsoils. Most of these lie in the southern and eastern parts of the region. The area of sandy soils that commonly have fine grained subsoils have a moderate to low potential for recharge. These generally occur along or adjacent to the major rivers. Clayey soils are generally dark with clayey subsoils, although in some places they consist of loamy soils and loamy subsoils in loamy redbeds or alluvium. As a general rule, they have the least potential for natural recharge and cover a large percentage of the study area. On the basis of the map in Fig. 25, one would assume, all other factors being equal, that the greatest amount of natural recharge to the Garber-Wellington would occur in the southern and east-central parts of the study area and adjacent to the major rivers.

Records of 21 gaging stations were examined for water years 1973 (wet), 1976 (dry), and 1978 and 1979 (normal), although records for all gages were not available for all of the years. Remarks concerning these gages are given in Table 1. Because of the distribution pattern of precipitation, some areas had more rainfall during 1976 than during 1978. In this case the lower recharge value was used for dry period. Furthermore, since precipitation tends

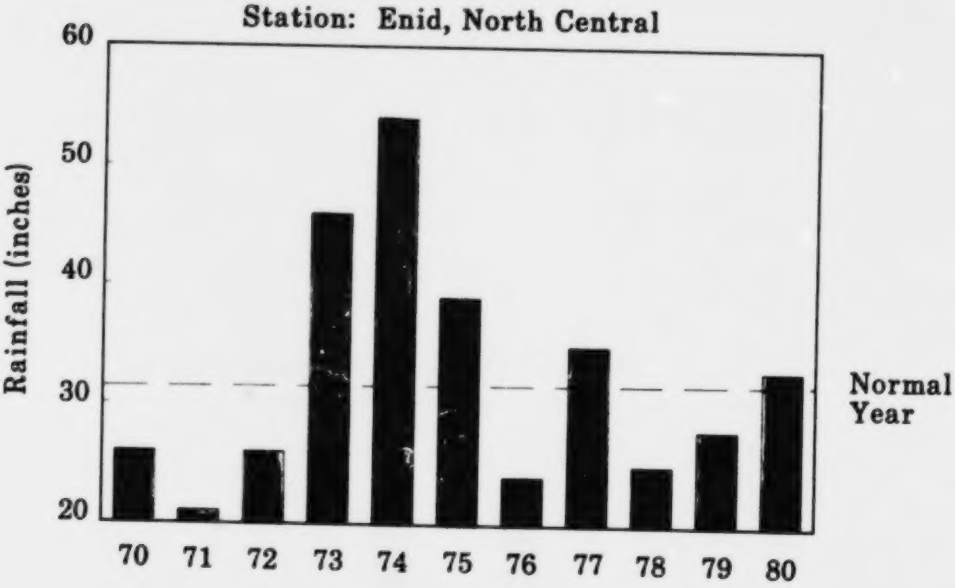


Figure 19. Mean Annual Precipitation for Water Years 1970–1980

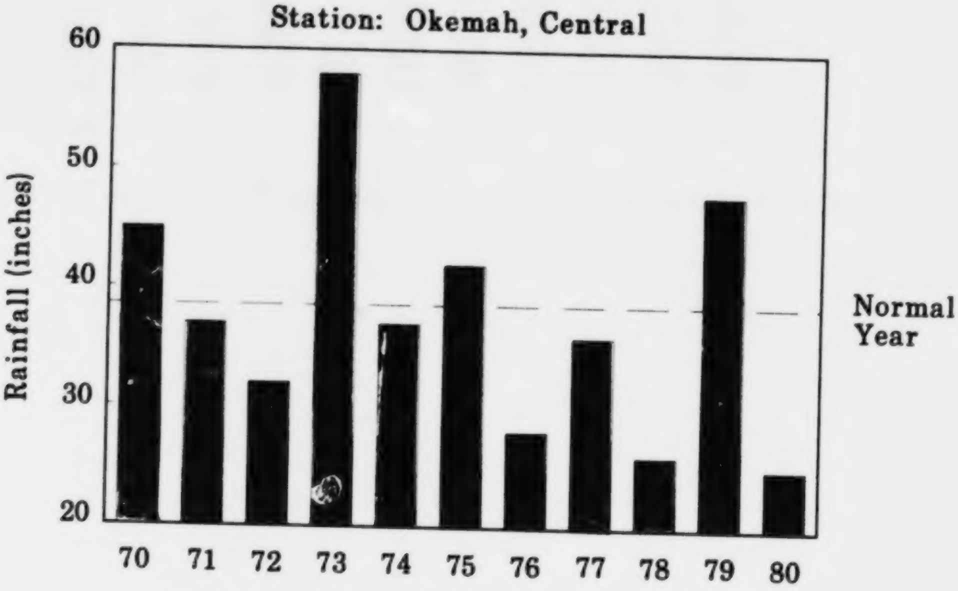


Figure 20. Mean Annual Precipitation for Water Years 1970–1980

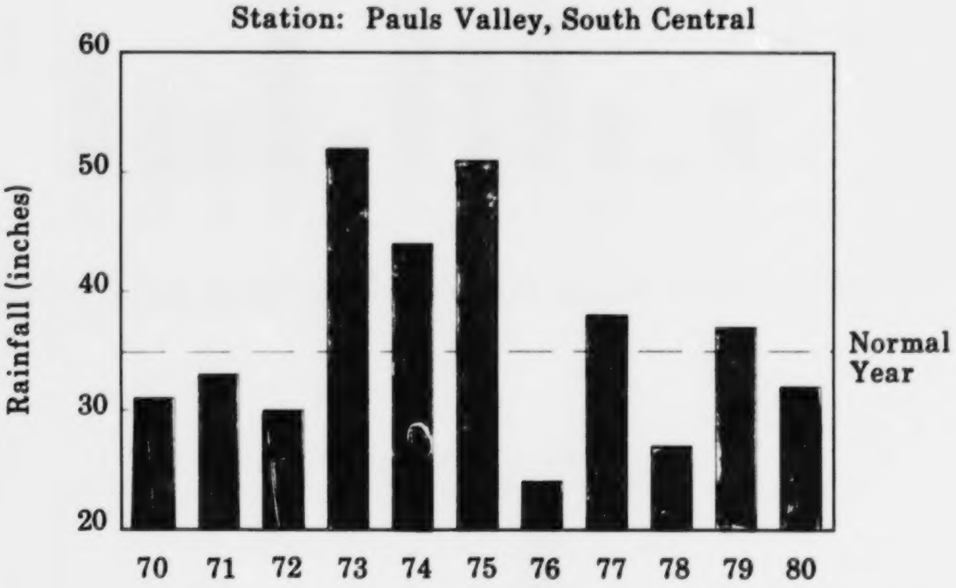


Figure 21. Mean Annual Precipitation for Water Years 1970–1980

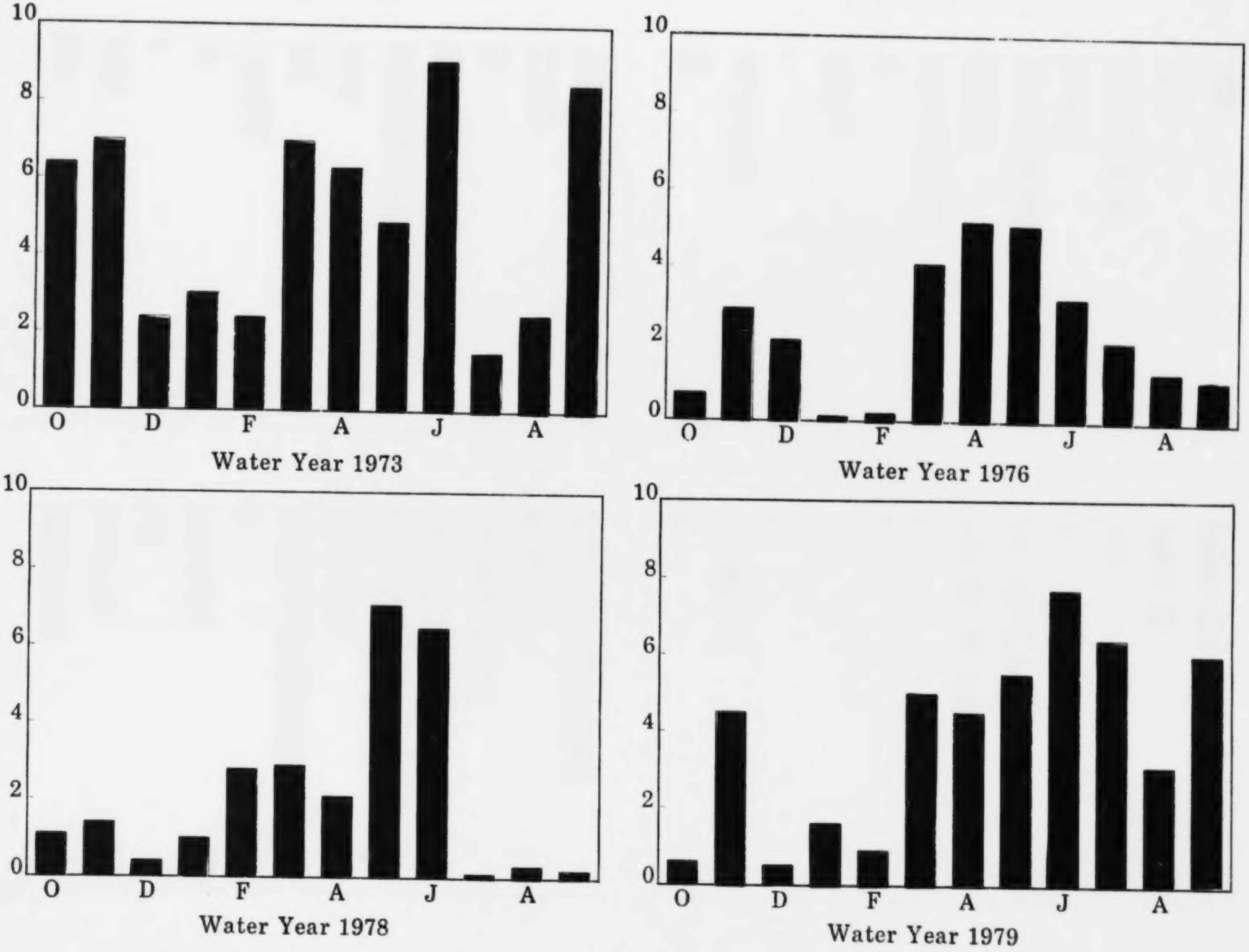
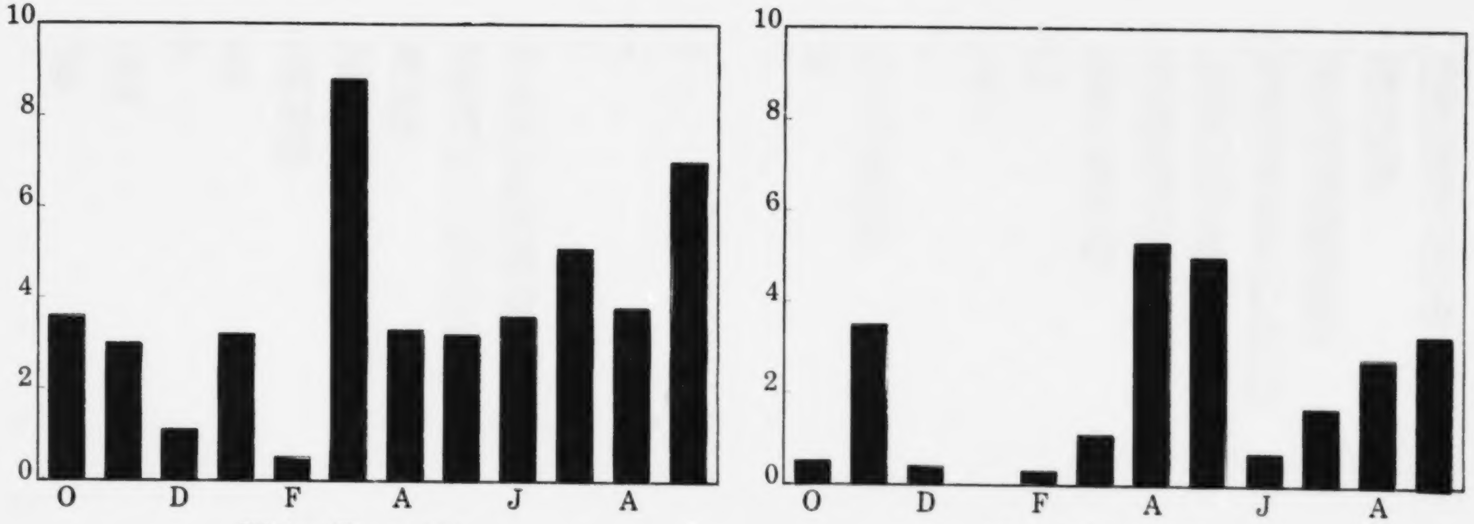
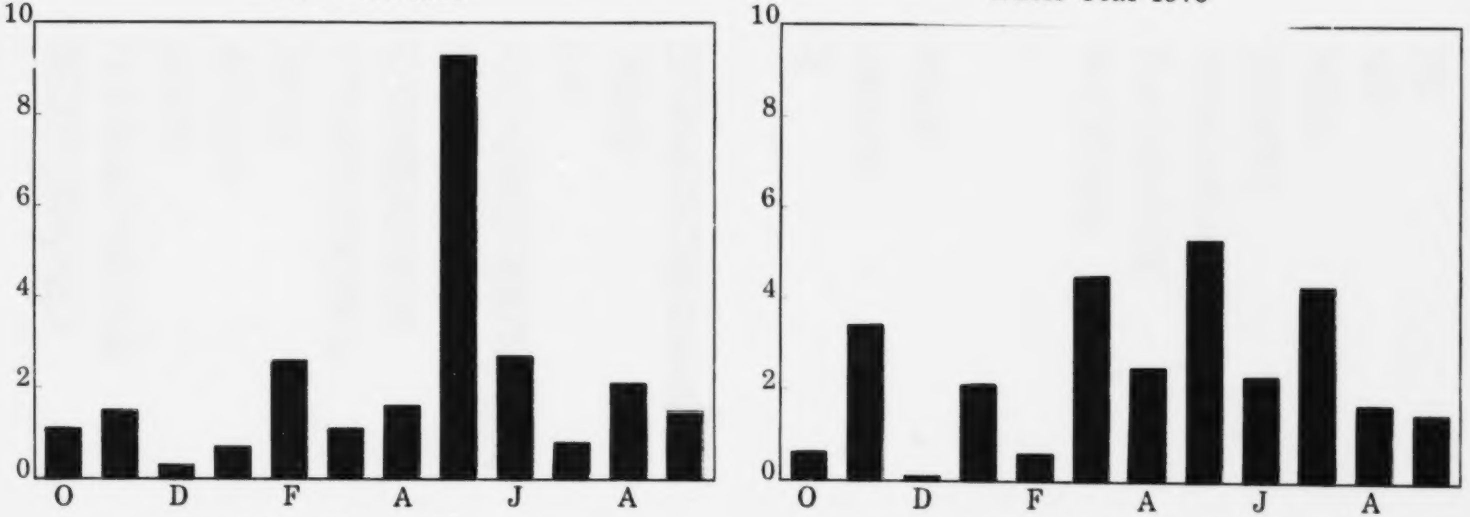


Figure 22. Okemah Monthly Precipitation for Water Years 1973, 1976, 1978, 1979



Water Year 1973

Water Year 1976



Water Year 1978

Water Year 1979

Figure 23. Enid Monthly Precipitation for Water Years 1973, 1976, 1978, 1979

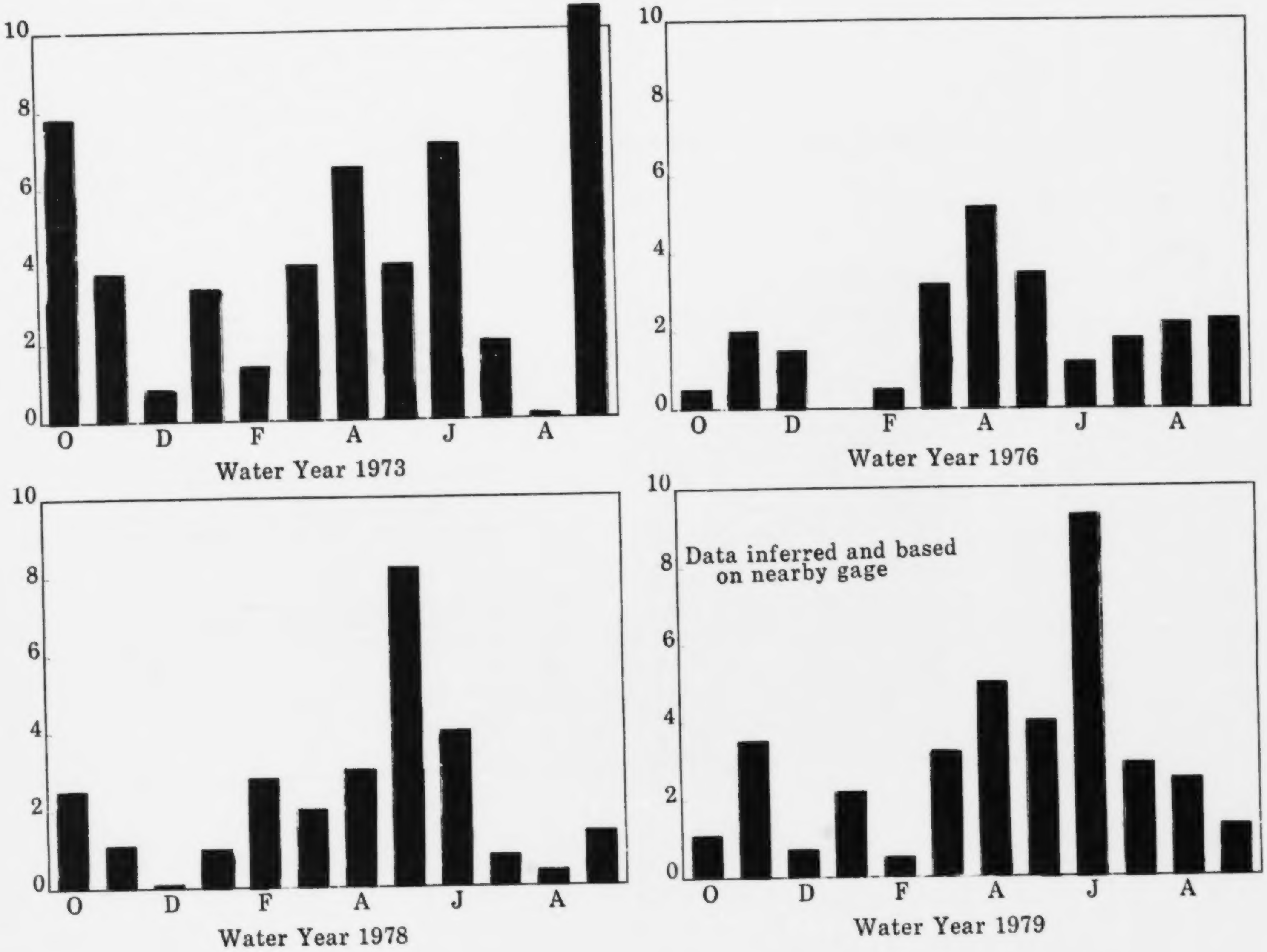


Figure 24. Paul's Valley Monthly Precipitation for Water Years 1973, 1976, 1978, 1979

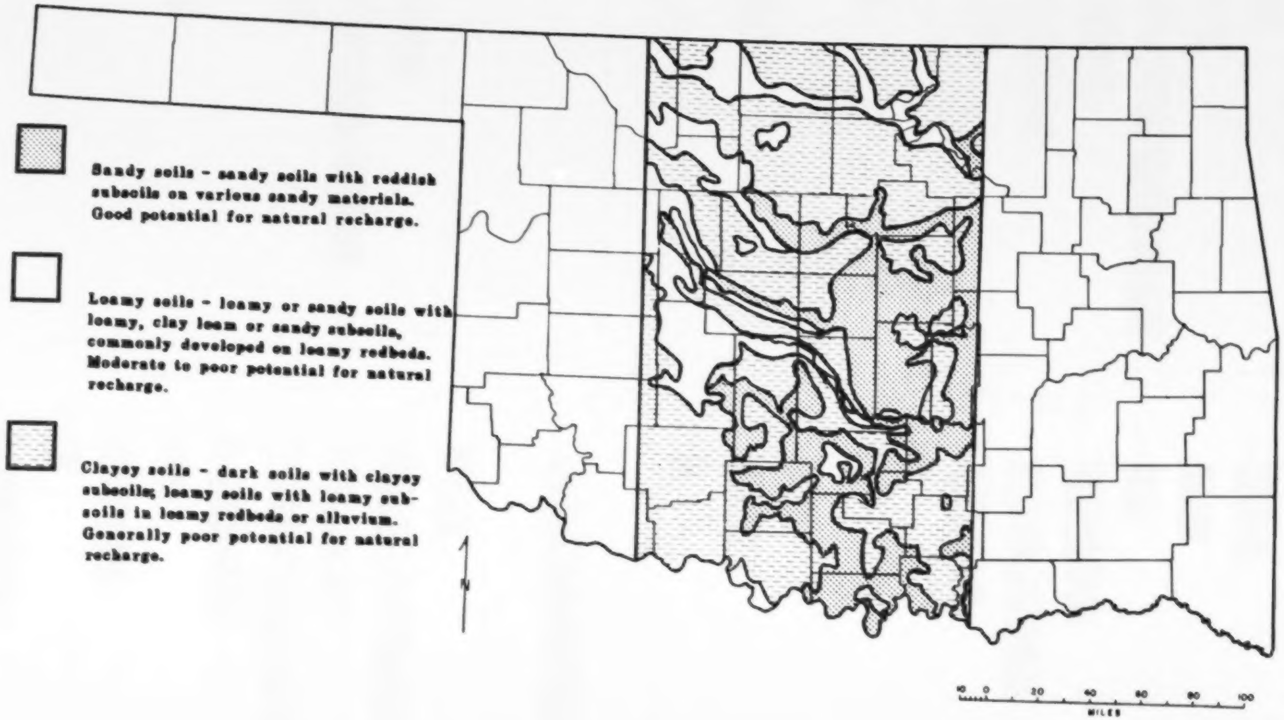

Sandy soils - sandy soils with reddish subsoils on various sandy materials. Good potential for natural recharge.
Loamy soils - loamy or sandy soils with loamy, clay loam or sandy subsoils, commonly developed on loamy redbeds. Moderate to poor potential for natural recharge.
Clayey soils - dark soils with clayey subsoils; loamy soils with loamy subsoils in loamy redbeds or alluvium. Generally poor potential for natural recharge.
N
10 0 20 40 60 80 100
MILES

Figure 25. Generalized soils map for Central Oklahoma.

TABLE 1

INFORMATION ON STREAM REGULATION OR DIVERSION

Station Number	Remarks
1510	Some regulation by Great Salt Plains Lake.
1520	Some regulation at low flow by Lake Carl Blackwell. Small diversion made from reservoir for municipal supply.
1525	Some regulation by John Martin Reservoir in Colorado and Great Salt Plains Lake.
2291	Extreme low flow sustained by sewage from Norman, occasional slight regulation by reservoir in Texas and New Mexico.
2300	Flow completely regulated by Lake Thunderbird.
2305	Flow regulated or diverted by Lake Thunderbird.
2310	Flow regulated by Lake Thunderbird.
2395	Some regulated by Canton Lake.
2400	Canal from Canadian River to Lake Hefner.
2415.5	Low flow sustained in part by sewage effluent from Oklahoma City.
3274.9	Small diversions above station for irrigation.
3280.7	Flow regulated by 16 flood-retarding structures, minor diversions for irrigation above station.
3281	Regulated by Fort Cobb and Foss Reservoirs and several flood-retarding structures.
3285	Same as above, some irrigation diversions above station.
3297	Flow regulated by flood-retarding structure and reservoirs.

to increase southeastward, higher recharge rates south of the Washita River probably reflect this difference. Data for water year 1979, which probably closely reflects the long-term average, are shown in Table 2. Data for 1973, 1976 and 1978 are shown on Plate 1.

Other than the large basins (Arkansas, Cimarron, North and South Canadian, Washita) only one water course (Little River) was recorded by more than one gage. Records indicate a substantial recharge rate increase from west to east. For example, the flow recorded at three gages on Little River are regulated by Lake Thunderbird. Nonetheless, since all gages are below the lake, the effect of regulation is cancelled. Two gages lie within the outcrop area of the Garber-Wellington (Plate 1). The upstream gage (2300) has a 257 square-mile drainage basin; the drainage basin of the next downstream gage (2305) encompasses 456 square miles. On the average, the effective recharge rate, in gallons per day per square mile, between the upstream and downstream gages is twice as large as that above (west of) the upper gage during wet periods and more than 6 times greater during normal (1978) and dry years (1976).

A particularly useful method for evaluating stream flow consists of relating the discharge to the size of the drainage basin (cfs/sq. mi.). During water year 1979 the upper gage on Little River (2300) had a mean daily flow of 7.51 cfs and the lower gage (2305) had a flow of 65.5 cfs, which represents a considerable increase in discharge. When divided by the size of the drainage basin (in order to determine the flow index), the values are .029 and .144 cfs/sq. mi., respectively. During the 90% flow (the flow equalled or exceeded 90% of the time), these values are considerably smaller but the general pattern continues. During 1973 they were .0000039 cfs/sq. mi. and .0000088 respectively, and in 1976 they were

TABLE 2

EFFECTIVE GROUND-WATER RECHARGE RATES FOR WATER YEAR 1979

Water Course	Station Number	Recharge rate, gpd/sq. mi. and inches Fixed Interval		Sliding Interval		Local Min.	
Wildhorse Creek	3297	83,000	1.74	67,000	1.41	15,000	.32
Winter Creek	3280.7	134,000	2.83	143,000	3.02	61,000	1.29
Little Washita	3274.9	101,000	2.13	99,000	2.09	56,000	1.18
Dry Creek	2430	65,000	1.38	67,000	1.41	12,000	.26
Deep Fork*	2423.5	396,000	8.33	396,000	8.32	257,000	5.4
Little River	2300	13,000	.28	13,000	.29	1,354	.03
Little River	2305	73,000	1.54	59,000	1.25	33,000	.70
Little River	2310	111,000	2.35	107,000	2.27	22,000	.46
Walnut Creek	2293	113,000	2.38	115,000	2.42	54,000	1.15
Council Creek	1630	181,000	3.82	175,000	2.70	19,000	.42
Skeleton Creek	1605	101,000	2.14	97,000	2.05	25,000	.54
Black Bear Creek	1530	100,000	2.11	99,000	2.10	14,000	.31
Salt Fork	1510	73,000	1.53	70,000	1.48	4,470	.09
Chickaskia River	1520	103,000	2.18	105,000	2.21	20,000	.43

*Influenced by discharge of sewage effluent

.000012 and .000029. In 1979, however, they were reversed (.0000075 and .0000022, respectively), very likely because of diversion for irrigation.

Regardless of the technique used, it is evident that the flow increases downstream at a rate that is not uniform throughout the drainage basin. This indicates that natural recharge to the Garber-Wellington in the basin of Little River is larger than elsewhere. It also indicates that the aquifer in this area is full to overflowing and that it discharges into streams.

Elsewhere an analysis can be provided only in general terms because of the limited number of gages, the unusually large size of the drainage basin, or external effects on the stream brought about by regulation or the discharge of effluent. For example, gage 2423.5 on Deep Fork provides records that indicate a recharge rate that is about four times larger than surrounding stations (Plate 1). The high and consistent flow is the result of discharge of municipal sewage effluent into the stream.

The very large basins (Arkansas, Cimarron, North and South Canadian, and Washita) cannot be adequately examined because the computer analysis results in values that are much too low. The computer program is based on the assumption that natural recharge occurs, at least in a general way, more or less uniformly throughout the basin. In these basins, however, two distinctly different types of strata appear--consolidated rocks of relatively low permeability and alluvial or sand dune deposits that are quite permeable. Presently it is not possible to separate the stream flow into the quantities derived from the different strata. Eventually it should be possible to do this with a more refined program that is based in part on differences in water quality. On the other hand, it isn't necessary to use data from gages on the major rivers because their gaged tributaries provide the same information and are influenced by far fewer externalities.

From a natural recharge point of view the Garber-Wellington outcrop area can be divided into three rather broad zones. Zone A extends southward from the Kansas-Oklahoma border to the southern part of Noble County. Here the major or gaged water courses include the Arkansas and Chikaskia River, Salt Fork, and Black Bear Creek. In this region effective groundwater recharge rates during a wet year (1973) were about 102,000 gpd/sq. mi. (2.1 inches) and during a normal year (1979) were about 92,000 gpd/sq. mi. (1.9 inches).

Zone B extends southward from the northern part of Payne County to the headwaters of Little River in Cleveland County. Here recharge during 1973, 1976, and 1978 was about 58,000 gpd/sq. mi. (1.2 inches), 10,000 (.21 inches) and 21,000 (.44 inches), respectively. These data are representative of the western less-permeable part of the study area and the rates are quite likely larger eastward. During 1979, however, which is more typical of a normal year although wetter, the average rate is about 105,000 gpd/sq. mi. (2.21 inches).

Zone C extends southward through Wildhorse Creek basin. Recharge rates in Zone C during wet, dry, and normal years average about 99,000 gpd/sq. mi. (2.7 inches), 23,000 (.48 inches), and 41,000 (.86 inches), respectively. Data for individual sites are shown in Plate 1. Recharge in 1979 averaged about 92,000 gpd/sq. mi. (1.9 inches) in the Garber-Wellington outcrop area.

The average effective recharge rates described above are influenced, to a large degree, by precipitation events and patterns. Since annual precipitation increases towards the southeastern part of the state, the higher recharge rates along and south of the Washita River basin probably reflect this difference. Furthermore, precipitation patterns during the years studied were not uniform and fluctuated rather widely from one place to the next. Considering all the data, it would appear that the average effective ground-water recharge rate for the unconfined part of the Garber-Wellington Aquifer is about 100,000 gpd/sq. mi., or about 2.11 inches. On most appraisals, this is the rate that should be considered. Recharge rates expressed in inches are shown in Table 3.

The frequency of droughts and wet periods also have a subtle effect on the hydrologic system. For example, a wet year following months or years of dry weather will not influence stream flow or ground-water recharge as much as a wet year following a normal or wet year. In part, this is due to a large share of the water being used to replace the soil-moisture deficiency and there may be little excess for surface runoff or ground-water recharge. Resultingly, there may be a large difference in calculated effective recharge rates from one year to the next or from place to place.

The preliminary estimates of effective ground-water recharge rates described herein reflect only a short time span and, consequently, are subject to revision. Another project is presently underway by the author to evaluate rates using a 10-year continuous data base. This study will result in effective recharge rates that are less influenced by uncommon precipitation events or periods. On the other hand, recharge rates during dry years are important, particularly for planning purposes, because it is during dry periods that wells must withdraw largely from storage.

Recharge rates for other areas in Oklahoma have been determined by a variety of methods by graduate students in the Department of Geology at

TABLE 3

EFFECTIVE GROUND-WATER RECHARGE, IN INCHES

Station No.	1973	1976	1978	1979
1510	[1]2.51	0.56	0.62	
	[2]2.31	0.56	0.59	
	[3]1.49	0.53	0.46	
1520	2.37	0.85	1.11	2.18
	2.17	0.87	1.12	2.21
	1.75	0.82	1.08	.43
1525	1.40	0.40	0.56	
	1.26	0.42	0.57	
	1.07	0.32	0.53	
1530	2.05	0.26	0.21	2.11
	2.10	0.26	0.22	2.10
	1.09	0.23	0.18	.31
1605	0.99	0.50	0.29	2.14
	1.01	0.50	0.30	2.05
	0.92	0.46	0.27	.54
1610	0.76	0.21	0.18	
	0.63	0.22	0.17	
	0.57	0.21	0.18	
1630	1.35	0.31	0.38	3.82
	1.34	0.31	0.45	3.70
	1.20	0.30 (1967)	0.30 (1968)	.42
2291	0.09	0.05	0.10	
	0.09	0.04	0.10	
	0.09	0.02	0.04	
2293	2.84	1.17	0.28	2.38
	2.84	1.16	0.30	2.42
	2.82	1.10	0.24	1.15
2300	1.23	0.05	0.03	.28
	1.39	0.05	0.03	.29
	0.59	0.05	0.03	.03
2305	2.90	0.33	0.18	1.54
	3.03	0.33	0.17	1.25
	2.65	0.32	0.13	.70
2310	3.70	0.53	0.48	
	3.62	0.55	0.50	
	3.39	.047	0.40	
2395	0.10	0.03	0.05	
	0.10	0.04	0.05	
	0.18	0.03	0.04	
2415.5	0.25	0.10	0.09	
	0.23	0.10	0.09	
	0.21	0.10	0.09	
2423.5	5.11	3.51	3.29	8.33
	5.12	3.50	3.30	8.32
	4.75	3.48	3.20	5.40
2430	1.32	0.98	0.17	1.38
	1.32	.096	0.16	1.41
	1.25	0.90	0.15	.26
3274.9	1.60	1.45	0.80	
	1.64	1.44	0.82	
	1.50	.139	0.77 (1975)	
3280.7	4.57	1.34	5.86	2.13
	4.45	1.36	6.30	2.09
	3.74	1.22	4.80 (1968)	1.18
3281	0.78	0.66	0.78	
	0.70	0.65	0.77	
	0.66	0.62	0.28	
3285	0.94	0.71	0.70	
	0.90	0.71	0.69	
	0.78	0.68	0.69	
3297	2.38	0.90	0.84	1.74
	2.39	0.84	0.70	1.41
	2.16	0.69	0.49	.32

[1]Fixed Interval; [2]Sliding Interval; [3]Local Minima

Oklahoma State University. Generally, the rates were based on computerized ground-water flow models, and thus recharge was not actually measured but rather estimated by calibrating each model. The calibrations were based on long-term averages. In most cases only the most permeable areas were modeled.

The Enid Terrace was investigated by Beausoleil (1981). Using well hydrographs and precipitation data for this model, he concluded that the natural recharge rate was about 2.3 inches/year (109,500 gpd/sq. mi.). Lyons (1981) in his study of the Elk City-Washita area, calculated a recharge rate of 3.92 inches/year (186,630 gpd/sq. mi.), which is 14.1% of the long-term precipitation rate. The North Fork of the Red River was investigated by Paukstartis (1982). He estimated a long-term recharge rate of 2.28 inches/year (108,550 gpd/ sq. mi.), which was equivalent to 9.4% of the total runoff. Shipper, whose work is still in progress, studied part of the Washita basin. His preliminary estimate of recharge through permeable alluvial deposits is 3.3 inches/year (157,100 gpd/sq. mi.).

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Appendix VII

DETAILED WORK PLAN
FOR A
NATIONAL GROUNDWATER RESEARCH PROJECT
ON THE
GARBER-WELLINGTON AQUIFER

LEGAL FACTORS
(Task 903.01)

THE LEGAL FRAMEWORK FOR THE PROTECTION DEVELOPMENT AND MANAGEMENT OF THE GARBER-WELLINGTON AQUIFER PURSUANT TO 82 O.S. 1981, §§1020.1 et seq.

Submitted by

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March, 1983

THE LEGAL FRAMEWORK FOR THE PROTECTION, DEVELOPMENT AND MANAGEMENT OF THE GARBER-WELLINGTON AQUIFER PURSUANT TO 82 O.S. 1981, §§1020.1 et seq.

The following material generally outlines and summarizes the existing state laws and regulations related to water rights in the State of Oklahoma. Particular emphasis is given to existing laws and the legal framework that will impact upon the development of the Garber-Wellington Aquifer. The starting point for this report on ground water laws must necessarily begin with an examination of the Oklahoma Statutes applicable to ground water, especially the Oklahoma Ground Water Law, which is found at 82 O.S. 1981, §§1020.1 through 1020.22, inclusive. The current Oklahoma Ground Water Law was passed in 1972 and became effective July 1, 1973.

I

Basic Legal Framework

The basis for the ground water law, the regulations thereunder, and the system of water rights administration in Oklahoma originates in 60 O.S. 1981, §60. This section states in relevant part:

> "The owner of the land owns water standing thereon, or flowing over or under its surface but not forming a definite stream. The use of ground water shall be governed by the Oklahoma Ground Water Law. . ."

Thus it is apparent that the entire system of ground water law administration and regulation is based upon the premise that the owner of the land owns the water thereunder. However, further reading of this section indicates that this "ownership" is not an unqualified right. Section 60 reminds us that the "use" of the ground water is to be governed, controlled and managed according to the provisions of the ground water law.

In an effort to fully understand the regulatory system proposed and implemented by the ground water law, it is necessary to look at the policy declared by the Oklahoma Legislature when the act was adopted. Title 82 O.S. 1981, §1020.2 states this policy as follows:

> "It is hereby declared to be the public policy of this state, in the interest of the agricultural stability, domestic, municipal, industrial, and other beneficial uses, general economy, health and welfare of the state and its citizens, to utilize the ground water resources of the state, and for that purpose to provide reasonable regulations for the allocation for reasonable use based on hydrologic surveys of fresh ground water basins or subbasins to determine a restriction on the production, based upon the acres overlying the ground water basin or subbasin. . ."

Thus the Legislature passed this act with the intention, paraphrased, that the ground water resources of the state be utilized for beneficial uses including but not limited to agriculture, domestic, municipal and industrial uses and to provide reasonable regulations restricting production in the interests of the general economy and health and welfare of the state and its citizens. It is apparent that the Legislature sought to provide for utilization of the ground water resources of the state, yet realized that some sort of restriction on production was needed, and set forth the procedures in subsequent sections of Title 82 necessary for said restriction on the use of the ground water.

It is apparent from a review of the underlying policy concerning ground water use and regulation that there are no legal preferences or priorities among competing uses for the right to place water to beneficial use in Oklahoma. Not only is there an absence of statutory authority for establishing preferences and priorities among different uses (for example: municipal use being given a preference or priority over agricultural or industrial use), but §1020.2 rather lumps all beneficial uses to be utilized together and puts them on equal footing. Thus, every permit holder allowed to withdraw ground water from the Garber-Wellington is on equal legal footing with every other permit holder, there being no priority in time or preference among competing uses for the water except for those persons with rights perfected prior to the present law.

As contemplated by the ground water statutes, the first major step in the utilization of ground water resources through allocation for reasonable use is the making or conducting of hydrologic surveys and investigations. The ground water law directs that the Oklahoma Water Resources Board make hydrologic surveys and investigations of each fresh ground water basin or subbasin and authorizes the Board to cooperate with state and federal agencies in making these surveys and investigations and, further, requires the Board to update said hydrologic surveys at least every ten years. (82 O.S. 1981, §1020.4).

The second step in the information gathering process requires the Board, after making the hydrologic surveys, to make a determination of the maximum annual yield of fresh water to be produced from each ground water basin or subbasin. The third step entails the setting of a "tentative maximum annual yield for the basin" and the Board calling and holding hearings on said tentative maximum annual yields. After these hearings are completed, the Board then proceeds to make a final determination as to the maximum annual yield of water which shall be allocated to each acre of land overlying such basin or subbasin. 82 O.S. 1981, §§1020.5 and 1020.6.

The process by which hydrologic surveys and investigations are made and conducted is quite complex and involves considerable time and expense. Section 1020.5 provides certain guidelines and criteria upon which a determination of maximum annual yield is to be formulated. The determination of maximum annual yield of fresh water to be produced from a ground water basin must be based upon the following:

1) The total land area overlying the basin or subbasin;

2) The amount of water in storage in the basin or subbasin;

3) The rate of natural recharge to the basin or subbasin and total discharge from the basin or subbasin;

4) Transmissibility of the basin or subbasin; and

5) The possibility of pollution of the basin or subbasin from natural sources.

In determining "total discharge" for purpose of maximum annual yield, the Board must determine who possessed ground water rights prior to the effective date of the current ground water law, and in what amounts and for what purposes. Section 1020.14 (of Title 82) instructs the Board that:

> "Nothing in this act shall be construed to deprive any person of any right to the use of groundwater in such quantities and amounts as were used or were entitled to be used prior to the enactment hereof. Any person having the right to place groundwater to beneficial use prior to the effective date of this act shall have the right to bring his use under the provisions of this act."

Since the Board is not allowed to construe the statutes in such a manner as to deprive persons of the quantities as were used or entitled to be used prior to the enactment of the present law, and since ground water withdrawals under authority of a "prior right" constitute discharges from the basin, the Board conducts administrative proceedings on a county-by-county basis to determine these prior rights. Once the Board quantifies the prior rights in the counties that comprise the ground water basin and the Board issues its Order declaring same, the total amount of water attributable to prior rights is deducted from the amount of water in the basin determined by a hydrologic study in order to quantify the amount available for allocation to owners of land overlying the basin.

The Board's authority to administratively determine prior ground water rights pursuant to 82 O.S. §1020.14 has been legally challenged but was upheld by the Supreme Court of Oklahoma in the case of Field and Petty v. OWRB, 645 P.2d 511 (1982). In this case the Court upheld the Board's position that the plaintiffs did not possess a prior right to withdraw water from the Ogallala ground water basin in Texas County based upon their 1970 first use of the water in the absence of a permit allowing the withdrawal of water. In summary, the Court held that actual prior use without compliance with prior legislative provisions to obtain a permit to withdraw water was not a basis upon which to grant plaintiffs a prior ground water right with a priority date earlier than the effective date of the current ground water law.

Another guideline the Board must take into consideration is that the maximum annual yield of each fresh ground water basin or subbasin shall be based upon a minimum basin or subbasin life of twenty (20) years from the effective date of the Ground Water Law (July 1, 1973).

In an effort to assure input from interested persons, the law further requires the Board to make copies of the hydrologic survey available for inspection and examination by all interested persons and to hold administrative public hearings on the Board's tentative determination. Hearings are held at centrally located places within the basin area. At these hearings, the Board is directed to present evidence of the geological findings and determinations upon which the tentative maximum annual yield has been based. Any interested party has the right to appear and present evidence in support or opposition to the Board's tentative determination of the maximum annual yield. Once this information has been received, reviewed and considered, the Board then proceeds to make its final determination as to the maximum annual yield of the water to be allocated to each acre of land overlying such basin or subbasin. It should be noted that the statutes allow the Board in subsequent basin or subbasin hearings to increase the amount of water allocated to each acre, but not to decrease the amount of water allocated.

The Legislature also carved out certain exceptions from the permitting requirements of the ground water law. One exclusion from the permitting requirements is found at 82 O.S. 1981, §1020.3 which states "Any landowner has a right to take ground water from land owned by him for domestic use without a permit." Another exclusion is found at §1020.2 which provides that "the provisions of this act shall not apply to the taking, using, or disposal of salt water associated with the exploration, production or recovery of oil and gas or to the taking, using, or disposal of water trapped in producing mines." For purposes of the ground water law, "Fresh water" is water having less than five thousand (5,000) parts per million total dissolved solids, with all other water being "salt water".

II

The Application and Permitting Process

In Oklahoma, the application and permitting requirements may generally be found in the statutes at 82 O.S. 1981, §§1020.7 through 1020.11 inclusive. These statutes require that:

> "Any person intending to use ground water shall, after his testing is completed, make application to the Board for an appropriate permit as provided in Section 11 before commencing any drilling for such purposes and before taking water from any completed well heretofore drilled."

One notable exclusion to this requirement is that any landowner has a right to take ground water for domestic use without a permit from land owned by him. "Domestic use" by law means the use of water by a natural individual or by a family or household for household purposes, for farm and domestic animals up to the normal grazing capacity of the land and for the irrigation of land not exceeding a total of three acres in area for the growing of gardens, orchards and lawns.

The law requires that applications to take and use ground water be on forms provided by the Board which must be completed pursuant to the rules and regulations established by the Board. Each blank on the application must be filled in with all relevant data as accurately and completely as possible. Any applicant not owning land to be irrigated must obtain written permission from the landowner to make the application.

Of particular importance in the application process is that a full legal description of each tract of land and the location of each well to the nearest ten-acre subdivision be given. The applicant must state the purpose for which the ground water is to be used and must state if wells for domestic, stock, irrigation, or other purposes exist within one-half mile or less from the proposed well. Additionally, the applicant must furnish names and mailing addresses of all adjacent landowners and the applicant cannot be his own adjacent landowner.

The Board is directed to hold a hearing upon each application filed. Once an application is filed which complies with the provisions of the law and the Board's rules and regulations, the applicant is instructed to publish a notice of the upcoming hearing on the application in a newspaper in counties designated by the Board. This notice is published, at the applicant's expense, once a week for two consecutive weeks in a newspaper of general circulation in the county in which the well is to be located. The applicant is also required to give further notice by certified mail to all immediately adjacent landowners. These notices set forth all of the pertinent facts contained in the application as to the proposed well location, the amount of water, the place and purpose of use, the name and address of the applicant, the time when and the place where the application will be taken up by the Board for consideration. At the hearing on the application, the Board's Hearing Examiner receives evidence presented by the interested parties. Hydrologic surveys and other relevant data may also be entered into evidence. This evidence is used by the Board to determine whether an applicant meets the four conditions outlined in 82 O.S. 1981, §1020.9 for the granting of a ground water permit. Paraphrased, these statutory conditions are:

1) That the lands dedicated to the application are owned or leased by the applicant (a valid lease permitting withdrawal of the ground water);

2) That the lands dedicated overlie the fresh ground water basin or subbasin;

3) That the applicant's intended use is a "beneficial use"; and

4) ". . .that waste will not occur. . ." by virtue of the intended use.

It is clear that, prior to issuing any ground water use permit, the Board must make a finding and determination that waste will not occur by virtue of the intended use subject of the application. This finding is a jurisdictional prerequisite to the issuance of a permit and is an affirmatively required Board finding and determination. The issue of "waste" is a statutory issue which is made applicable to all application proceedings. "Waste" is discussed in-depth in Subpart III, protection of Ground Water.

In connection with the granting of ground water applications, it should be noted that there are four types of ground water permits that may be obtained under the Ground Water Law, i.e. regular, temporary, special and provisional temporary permits. Each type of permit serves a different function and has a different time limit or duration.

A regular permit is the type of permit issued by the Board allowing ground water to be put to beneficial use and is a permit which has no termination date. Regular permits are granted only after completion of the hydrologic survey and after the maximum annual yield for the appropriate basin or subbasin has been determined by the Board. By statute, this type of permit may only be revoked or cancelled for willful failure to report annual usage and for violations of Oklahoma's "waste" statute (§§1020.12 and 1020.15).

A temporary permit is an authorization for the same purposes as a regular permit, but is granted prior to the completion of the hydrologic surveys and determination of the maximum annual yield of the basin or subbasin. A temporary permit must be revalidated annually during its term and lapses upon its expiration or the issuance of a regular permit, whichever occurs first. A unique feature is that, unless certain circumstances exist, the water allocated by a temporary permit may not be less than two (2) acre-feet annually for each acre of land owned or leased by the applicant in the basin and dedicated to the instant application. This feature of the temporary permit (allocating two acre-feet per acre) differs from the regular permit wherein the maximum annual yield may reveal that a landowner is entitled to use a different amount, either a greater or lesser amount per acre, from the two acre-feet per acre allowed under a temporary permit. Amounts in excess of two acre-feet are granted under a temporary permit if the applicant presents clear and convincing evidence that the allocation will not exhaust the water in the basin or subbasin in less than 20 years.

The third type of ground water permit issued is a special permit which may be used in lieu of or in addition to a regular or temporary permit. This type of permit is designed to be used when a specific beneficial use requires quantities of water in excess of that allocated under a regular or temporary permit. The special permit has several unique features contrasting it from the temporary or regular permit. As with all types of permits a specific purpose to which the water is to be placed is referenced in the "special" permit. However, the water authorized to be used under a special permit may be used only for that designated purpose, and no change of use may be made, as is possible for other types of permits. Another unique feature of the special permit is that the duration of the permit shall not exceed six (6) months but the permit may be renewed three (3) times. It should also be noted that successive special permits cannot be granted for the same purpose. This type of permit is subject to revocation or cancellation for the same statutory reasons as is a regular or temporary permit.

The fourth type of ground water permit issued by the Board is a provisional temporary permit. This type of permit is granted upon administrative approval, is nonrenewable, is effective for a period of not to exceed sixty (60) days and is subject to cancellation at any time during its term. Since this permit is granted upon administrative approval, no hearing is held, no application notice or data is published and no notice to adjacent landowners is required. This type of permit is only approved where the applicant's use is short term and the need is immediate.

The procedures for the granting of regular permits, including the four previously mentioned criteria for the granting of a ground water application, are applicable to all types of permits including temporary, provisional temporary or special type permits, except that the completion of a hydrologic survey is not a condition precedent for temporary, special or provisional temporary permits. Another provision which is applicable to all types of permits is that, with one exception, no permits shall be issued by the Board to any applicants who do not own the land on which the well is to be located or hold a valid lease from the owner of such land permitting withdrawal of water from such basin or subbasin. The single exception relates to municipalities drilling wells on platted lands within their city limits and is explained in more detail in Subpart IV (infra pg. 27).

The Board's rules and regulations provide that every permit issued by the Board shall contain substantially the following information:

1) Date of filing.

2) The permit number and date issued, which shall be the date the permit is approved by the Board or by the Executive Director in the case of provisional temporary permits.

3) The name and address of the person or entity to whom issued.

4) The amount of water in acre-feet and maximum rate of withdrawal in gallons per minute.

5) The proposed beneficial use and the legal description of the surface acreage dedicated to the permit.

6) The description of the well(s) to the nearest ten (10) acre subdivision, or by indicating "center of" when applicable for a larger tract of land.

7) In the case of irrigation, the number of acres to be irrigated and the legal description of same.

8) Ground water basin(s) from which water is to be withdrawn. (Provisional temporary permits are excluded from this requirement).

In addition, the permit may contain any additional terms, conditions, limitations, or restrictions the Board may prescribe.

Under provisions of 82 O.S. 1981, §§1085.2(10) and 1085.4, the Board is required to prepare and charge a schedule of fees. All fees are to be paid in cash or by check payable to and receipted by the Board. Fees must be submitted before any action will be taken. Permit fees are not refunded if the application for a permit is denied. The filing and permit fee schedule to withdraw ground water as of May 3, 1982 is as follows:

0 - 320 acre-feet	$ 25.00
321 - 640 acre-feet	$ 50.00
641 - 1,500 acre-feet	$ 75.00
Over 1,500 acre-feet	$100.00

Other fees required:

For the filing of a petition to add a well or change a well location	$ 25.00
For the filing of a petition to transfer ownership of a permit	$ 10.00
For the filing of a petition to subdivide the ownership of a permit	$ 25.00

Certain Fees are also required in the licensing of well drillers and operators.

Pursuant to the statutes and the Board's rules and regulations, each holder of a ground water permit must report the amount of water used annually under the permit. The statutes further provide that willful failure to report annual usage may result in cancellation of the permit by the Board upon proper notice and hearing as provided in the Administrative Procedures Act (Title 75 O.S. §§301 et seq.). Permit holders may voluntarily surrender a ground water permit, should a holder so desire, and forms for this purpose are available from the Board.

III

Protection of Ground Water

The prevention of and prohibition against "waste" or wasteful uses of water is a major tenet of western water law and policy and is of great importance to those persons using ground water from the Garber-Wellington Aquifer. As noted by Wells Hutchins:

> "Unnecessary waste of water generally has no rightful place in the water use economy of the West. Said a Florida court: 'As a general principle, equity abhors waste, and delights to restrain it in a proper case'. To waste water is to injure the public welfare; hence, it is the undoubted policy of the law to prevent its waste." (Hutchins, Vol. 1, "Water Rights Laws In The Nineteen Western States", Ch. 1, p. 12)

While Robert Emmet Clark generally defines "waste" as the loss of a resource (water) without substantial benefit, the concept of waste in western water law may, depending on context, variously relate to the quantity of water to be used in connection with any particular purpose; the location of the use; the purpose of the use; and, generally, the intended method and manner of use. Clark, "Waters and Water Rights", Volumes 1 and 7, Glossary and Chapter 4, pgs. 322 and 386, respectively.

While the concepts of "beneficial use" and "waste" are separate and distinguishable, the two are most directly and closely related. Beneficial use generally relates to and describes the nature and character of the particular use involved, i.e., irrigation, municipal, industrial, etc. However, an otherwise beneficial type of use may nevertheless be found to be a wasteful use due to the intended method of use or the amount of use for the particular purpose involved. Crop irrigation is, for example, a well-recognized beneficial use. However, the particular method of irrigation involved may be such that excessive amounts of water are lost in transit and the particular irrigation use would thus be rendered wasteful and, consequentially, non-beneficial. Clark, supra, Vol. 1, Ch.4, pgs. 382, 386. Conceptually, no wasteful use can be simultaneously recognized as a beneficial use, and to declare a particular use "beneficial" is to implicitly recognize the use as also being "non-wasteful". See generally, Atty. Gen. Op. No. 74-218.

Under the current Oklahoma Ground Water Law (82 O.S. 1981, §§1020.1 et seq., as amended), waste is statutorily addressed in four (4) different sections.

Section 1020.3, addressing a landowner's "domestic use" of ground water, provides (as noted earlier) that wells for domestic use are not subject to well spacing orders or the permit requirement, but, that such wells are subject to "sanctions against waste". Sections 1020.9 and 1020.11(D) set forth the conditions which must be established before a ground water use permit may be issued. Among the four (4) basic conditions are the conditions that the Board find that the intended use is a "beneficial use" and that "waste will not occur" by virtue of the use. Section 1020.15 prohibits the Board from permitting any fresh ground water user to commit waste by:

1) Drilling a well, or taking or using fresh ground water without a permit, except for domestic use;

2) Taking more fresh ground water than is authorized by the permit;

3) Taking or using fresh ground water in any manner so that the water is lost for beneficial use;

4) Transporting fresh ground water from a well to the place of use in such a manner that there is excessive loss in transit;

5) Using fresh ground water in such an inefficient manner that excessive losses occur;

6) Allowing any fresh ground water to reach a pervious stratum and be lost into cavernous or otherwise pervious materials encountered in a well;

7) Permitting or causing the pollution of a fresh water strata or basin through any act which will permit fresh groundwater polluted by minerals or other waste to filter or otherwise intrude into such a basin or subbasin;

8) Drilling wells or producing fresh ground water therefrom except in accordance with the well spacing previously determined by the Board;

9) Using fresh ground water for air conditioning or cooling purposes without providing facilities to aerate and reuse such waters; or

10) Failure to properly plug abandoned fresh water wells in accordance with rules and regulations of the Board and file reports thereof."

This section requires the Board to take certain remedial steps to enjoin the commission of waste where committed in the Board's presence or where reported to the Board by complaint. Section 1020.22, Title 82 O.S. Supp. 1972, declares that the commission of waste constitutes a misdemeanor offense punishable by fine.

From the statutory references, two general observations regarding Oklahoma's statutory treatment of waste may be made. First, it is clear that the issue and question of "waste" is of considerable significance under present law and policy. It is one of the few matters of legal restriction placed upon domestic ground water use, it is a jurisdictional prerequisite for the issuance of all permits, and, it is an expressly forbidden act, civilly and criminally. Second, "waste", as contemplated and addressed under current statute, relates primarily to the method and manner of use involved, that is, such aspects as the amount, location, method and manner of use involved in what otherwise constitutes a "beneficial use" of the water. However, under the statute (§1020.15, supra), the particular use involved may also constitute "waste" by definition, i.e., waste by "using fresh ground water for air conditioning or cooling purposes without providing facilities to aerate and reuse such water". Use without a permit or use in excess of that authorized by a permit also constitutes waste by definition under §1020.15.

While §1020.9 expressly requires a Board finding and determination that waste will not occur before a permit may be issued, two points of preliminary clarification regarding this basic finding should be noted.

First, the requirement that there be no waste is not absolute or unqualified. As to the intended method and manner of use involved, it is recognized that the "waste" which is prohibited is "waste" which is deemed unnecessary or reasonably unavoidable under the circumstances. As Hutchins states:

> "In the operation of diversion and distribution systems, it is impracticable to save every acre-foot of water. Some so-called waste is inevitable, depending quantitatively on the surrounding circumstances. Because of practical considerations, therefore, the inhibition against waste of water means unnecessary waste, which is not tolerated in the state policies relating to beneficial use of water." (Hutchins, supra, at p. 13)

Second, a Board finding that waste will or will not occur may address the issue of waste generally (amount, location, method and manner of use), or, may address specific acts of waste such as those enumerated in §1020.15. However, the Oklahoma Supreme Court has ruled that §1020.15, supra, contemplates and pertains to an "after-the-fact" condition and finding of waste, that is, §1020.15 is a provision intended to provide a procedure for criminal prosecution, injunction and suspension of a permit when and if waste occurs. Lowery v. Hodges, Okl., 555 P.2d 1016 (1976). In Lowery, the Court correctly reasoned that the §1020.9 requirement that the Board make a finding that waste will not occur before issuing a permit does not require the Board to specifically find that the ten (10) acts of waste defined at §1020.15 will not occur, the reasoning being that §1020.15. as noted supra, contemplates an after-the-fact finding of waste and remedies to enjoin it. While Lowery in no respect alleviated the necessity of a Board finding that waste will not occur before a permit may be issued, it did clarify the distinguishable applicability of §1020.15 in connection with that required finding.

Under §1020.9, a Board finding that waste will not occur by virtue of the intended use must be made before an application can be approved and a permit issued. The statute states that this Board finding and determination shall be made from:

> ". . .the evidence presented by the parties interested, from the hydrologic surveys and from other relevant data available to the Board and applicant. . ."

With regard to the evidence and proof required on the issue of waste in permit application proceedings, three general observations may be made.

First, and despite the fact that hydrologic surveys and other relevant data available to the Board may be resorted to as an evidentiary source, the ultimate burden of showing that waste will not occur rests with the applicant. In the final analysis, it is the applicant which has the burden of coming forward with evidence and proof necessary to establish the four (4) statutory elements which must be established before a permit may be issued. Lowery v. Hodges, supra. Accordingly, it is the applicant's burden to show that waste will not occur by virtue of the intended use subject of the application. In meeting this burden of proof, the applicant may appropriately rely to a degree upon the Board's specialized knowledge and expertise in this particular area as well as any other relevant Board files, records or other data. However, it is ultimately the applicant who has the burden of establishing that waste will not occur by virtue of the intended use.

Second, the Board's finding and determination on the question of waste must be a finding and determination supported and sustained by "substantial evidence" presented. In unprotested application proceedings, the issue of waste may, like other statutory issues, be treated and disposed of summarily and informally. However, since waste is a statutory issue, it is an issue which, in all contested proceedings, must be specifically addressed as a Board finding, the Board finding thereon must be supported by the record. 75 O.S. 1971, §309(g), 312, 322; Oklahoma Inspection Bureau v. State Board for Property and Casualty Rates, Okl., 406 P.2d 453 (1965); Allied Inv. Co. v. Okl. Securities Commission, Okl., 451 P.2d 952 (1969); Herrin v. Fedr. Aviation Admin., 418 F.Supp. 889 (D.C. Okl., 1976); Couch v. Udall, 265 F.Supp. 848 (D.C. Okl., 1967).

Third, the extent of proof or evidence required to establish that waste will not occur by virtue of a particular intended use will undoubtedly vary from case to case and this is unquestionably an issue which can only be determined on a case by case basis. However, at the very least it may be said that some minimal amount of evidence addressing an applicant's intended method or manner of use is necessary before any competent finding or determination on the question of waste may be made by the Board. The cases of Lowery v. Hodges, supra, and Hodges v. OWRB, 580 P.2d 980 (1978) are illustrative of the proof required on this issue.

In Lowery, supra, the parties challenging the irrigation use permit issued by the Board argued, among other things, that the applicant had failed to show in the Board's permit proceedings that waste would not occur by virtue of the applicant's intended use and that the Board had failed to adequately address the waste issue in its findings. In this case, the applicant had introduced some evidence on its intended method and manner of irrigation use, and on the waste issue the Court stated:

> "We would agree that an applicant must show what method he intends to use for irrigating a particular area; but once that information has been furnished the Board, it then has the authority to determine that waste will not occur. If the protestants think that waste will occur, they would need to present that evidence to the Board for its consideration. Here, the appellants introduced their plan to the Board and the plan was approved by the Board as not being wasteful."

> "If the plans submitted to the Board do not on their face demonstrate such waste, and the protestants fail to introduce evidence to substantiate that waste will occur, and the Board finds that waste will not occur, the statute (§1020.9) has been satisfied and further questions concerning waste must await completion of the project." (at 555 P.2d 1016, 1023)

The Supreme Court reaffirmed this position in Hodges v. OWRB, supra. That case also involved a challenge to the Board's issuance of a permit for irrigation use wherein the applicant had indicated through his evidence that he would use the subject water for spray irrigation and that he would comply with any suggestions made by the Soil Conservation Service and the Agricultural Stabilization and Conservation Service in that process. It was noted that this was the only evidence introduced by the applicant with regard to the method of irrigation subject of the application. In addressing the issue of waste and the Board's finding that waste would not occur by virtue of the intended use, the Court stated:

> "The reasoning in Lowery, supra, answers appellees questions concerning whether or not irrigation is a beneficial use and what proof it is necessary for an applicant to present that there will not be waste:
>
>> 'We would agree that an applicant must show what method he intends to use for irrigating a particular area; but once that information has been furnished the Board, it then has the authority to determine that waste will not occur. If the protestants think that waste will occur, they would need to present that evidence to the Board for its consideration.'

> "The only evidence presented to the Board in the case before us that would suggest waste was evidence that the total mineral content, measured in parts per million, of domestic wells in the area, might be increased when the irrigation water filters back into the ground water formation. This evidence relating to total mineral content, which is one indication of water quality, was not conclusive."
>
> "Because of the inconclusive nature of the evidence and because Mr. Smiley did testify that he would acquiesce to and follow any recommendations made by the [SCS] and [ASCS], we hold that the Board did not err in finding that waste would not occur if the permit was granted." (580 P.2d 980, at 982-983)

As can be seen from the two cases cited above, the courts have implicitly recognized that at the application hearing stage of the proceedings, a minimal amount of evidence may be acceptable with regard to the required Board finding that waste will not occur. However, the cases also recognize that in such contested proceedings, such minimal evidence addressing the applicant's intended method or manner of use is absolutely necessary before any competent finding on the waste issue can be made by the Board.

In further regard to the subject of "waste" in ground water proceedings, the question often arises as to whether or not the use of fresh ground water for recovery of oil and gas constitutes waste under the statutes and if it is waste, whether the Board in such cases has the authority to disallow the application or permit. Needless to say this has been a matter of concern to the Board and others for a number of years. Accordingly, advice of the Oklahoma Attorney General was sought and in Opinion 67-159 the Attorney General advised that, in the course of research and statutes reviewed, no statutory authority existed for the proposition that as a matter of law, the use of fresh water for this purpose constituted waste. However, the Opinion did note that the basis for any order entered by the Board approving this use must be that the involved fresh water use was a legitimate beneficial one; therefore, inherent in the order would be a determination that no waste, as defined in the applicable sections of Title 82, existed in the particular instance. According to the opinion, this was analogous to and agreed in principle with Canada v. City of Shawnee, 179 Okl. 53, 64 P.2d 694, pertaining to an owner's reasonable use of percolating water flowing under its land where the court held:

> "The owner of land may draw from beneath its surface as much of the percolating waters therein as he needs, even though the water of his neighbors is thereby lowered, so long as the use to which he puts it bears some reasonable relationship to the natural use of his land in agricultural, mining, or industrial and other pursuits, but he may not forcibly extract and exhaust the entire water supply for the community, causing irreparable injury to his neighbors and their lands, for the purpose of transporting and selling said water at a distance from and off the premises.
>
> "Section 11785, O.S. 1931, (60 O.S. 1961, §60), vesting ownership of percolating water in the owner of the land above it, does not thereby vest said owner with the right to such an unreasonable use as will enable him to destroy his neighbor's property by forcibly extracting and exhausting the common supply of water for sale at a distance; such use being subject to the same restrictions as are imposed upon ownership of other classes of property."

Therefore, applying the applicable law, the Attorney General reached the opinion that if the Board determined that the use of fresh water in a recovery project would constitute waste, the authority of the Board was such that the permit application could be disallowed.

In subsequent revisions of the Board's rules and regulations specific rules, in addition to the regular filing requirements, were imposed upon applicants filing for the use of fresh ground water for secondary oil recovery. These additional requirements were placed on oil companies simply to aid the Board in making its determination involving permit applications for this use of water. It may be noted that no such specific filing requirements are imposed on any other applicants filing for a beneficial use of water.

In 1977, the Supreme Court of Oklahoma was faced with the question of whether the use of fresh ground water in a water flood system for secondary oil recovery would constitute "per se" waste under the ground water law. The Court in Texas County Irrigation and Water Resources Association, Inc. v. Cities Services Oil Company, 570 P.2d 49 (1977), held that such use did not constitute "per se" waste, and affirmed the Oklahoma Water Resources Board's Order granting Cities Services a permit to use ground water since the statutory requirements were fulfilled.

Another legal factor to be considered in the protection of the waters contained within the Garber-Wellington Aquifer is the Board's development and updating of the Water Quality Standards. By statute, the Board is authorized to group waters in classes according to their present and future best uses, for the purpose of progressively improving the quality of the waters. Once these "present and further best (beneficial) uses" are established, then the Board adopts standards of quality consistent with the uses established. 82 O.S. 1981, §926.6A. Both the uses established and the standards may be modified or upgraded to the extent practical and in the public interest. When the 1982 Water Quality Standards of Oklahoma were adopted, the "uses" established for the Garber-Wellington Aquifer were as follows: irrigation, municipal and domestic, industrial, recreation, commercial, fish and wildlife, drilling oil and gas and housing development. These beneficial "uses" established for the Garber-Wellington Aquifer reflect the uses to which ground water is presently being put to use pursuant to the Ground Water Law.

These classifications and standards not only are important in the prevention of pollution, but also impact upon the development of the Aquifer and the lands overlying the Garber-Wellington.

IV

Management of Ground Water In The Garber-Wellington Aquifer

Effective management of the Garber-Wellington Aquifer may be implemented and accomplished by the use of the following institutional mechanisms, as outlined under present Oklahoma law: conservancy districts, master conservancy districts, irrigation districts, regional water distribution districts, or through the use of current management authority vested by the statutes in the

Oklahoma Water Resources Board. In order to utilize some of the above-mentioned alternatives, minor statutory amendments may be required. This section on management of the aquifer will explain, compare and contrast the alternatives, but it must be pointed out that no statutory amendments are necessarily needed to best manage the resources of the Garber-Wellington Aquifer. This is true because the best management vehicles available are probably already contained in the Oklahoma Ground Water Act (Title 82 O.S., 1981, §§1020.1 et seq.), if these sections are fully utilized by persons desiring to develop and protect the Garber-Wellington Aquifer.

One alternative under current law for management of the Garber-Wellington Aquifer would be by creation of a conservancy district as authorized by Title 82 O.S. Supp. 1980, §541 et seq. Relevant Oklahoma statutes indicate that conservancy districts may be created for a number of different purposes, including developing and providing water for domestic, industrial and agricultural use, as well as directly to persons within the district's territory. This may include the construction, operation and maintenance of storage, distribution, treatment, supply and other works, installation, improvements and facilities necessary or incidental thereto. The creation of a conservancy district begins by filing a petition with the clerk of the Supreme Court of the State of Oklahoma, signed by owners of at least fifty-one percent (51%) of the land area embraced by the proposed district. The Supreme Court shall then determine which

District Court of the State near the center or middle of the district is most convenient to hear and determine whether the statutory requirements for the creation of a district exists. A hearing is held by the district court and if the court finds that the requirements set forth in 82 O.S., §541b exists, then the district is created. Following the creation, a Board of Directors are elected with the powers to carry out the purposes set forth under the Conservancy District Act.

As indicated earlier, one of the allowable purposes for the creation of a district includes the construction, operation, and maintenance of storage, distribution, treatment, supply and other works, installations, improvements and facilities necessary or incidental thereto, thereby giving the conservancy district certain powers of management of the resources therein.

Another related institutional management mechanism is the master conservancy district. A conservancy district and a master conservancy district are distinguishable in that a master conservancy district may be created for the purposes allowed for a conservancy district plus five additional purposes. The main purpose for creating a master conservancy district is to coordinate the operations, works and facilities of two or more conservancy districts, or two or more municipal corporations and/or conservancy districts in an effort to pool the resources and, in some instances to enter into contracts with municipal corporations, persons, and public agencies for the furnishing to them of water. Thus in effect a master conservancy district is a district created including lands constituting all or parts of one or more conservancy and/or irrigation districts and/or municipal corporations and/or lands not included in any such area. The basic rules for organization and creation of said district are comparable to those for the creation of a conservancy district.

Another possible institutional vehicle which might be investigated for management of the Garber-Wellington Aquifer is the irrigation district. In Oklahoma, irrigation districts are organized pursuant to 82 O.S. Supp. 1973, §§277.1 et seq. An irrigation district is created whenever ten (10), or a majority of the holders of title to lands susceptible to irrigation from a common source or combined sources and by the system or combined systems of works, desire to provide for the irrigation of same join together to sign a petition and file for the organization of the district. The petition must be filed with the Oklahoma Water Resources Board and must contain certain requirements including the description of the lands to be included within the proposed district, names and addresses of all the electors within the proposed districts and a proposed plan of operation. A map showing the boundaries of the proposed district must be attached to the petition. As in the case of the creation of a conservancy district, the petition is set for hearing, except in this case, the hearing is held before a hearing officer of the Oklahoma Water Resources Board. Following sufficient and legal notice, a hearing is held at the nearest county seat to the district giving all interested persons opportunity to appear and be heard concerning the proposed organization of the irrigation district. Following creation of the district, bylaws are adopted, a board of directors is elected and certain powers are bestowed upon these directors. These powers include those set out in Title 82, §277.6 and include in relevant part: "manage and conduct the business affairs of the district, make and execute all necessary contracts, . . .establish equitable rules and regulations for the distribution and use of water among the owners of land within the district, and generally perform all such acts as shall be necessary to conduct the affairs of the district." The powers of the Board of Directors also include the power to make assessments or levy charges upon the owners of land within the district, and the collection of tolls and charges for water used, construct, use, maintain, repair and improve canals, wells, reservoirs and water supply distribution facilities, and to perform any lawful act necessary to provide sufficient water to each elector in the district.

Thus it is quite apparent that the Directors of an irrigation district possess broad and wide ranging powers and authority to conduct business on behalf of the district in the management of water as a natural resource. Of the different types of districts subject to creation for management purposes, the irrigation district seems most attractive for the Garber-Wellington Aquifer. This is especially true because of the powers to "establish equitable rules and regulations for the distribution and use of water among the owners of land within the district". However, to fully utilize this type of district, its powers would have to be increased to include more than just lands susceptible to irrigation, as current law provides. Also, the statute would also need to be amended to expand the powers of the district to include not only irrigation as a beneficial use, but all beneficial uses in Oklahoma. Should these statutory changes be accomplished, the irrigation district could serve an important role in local management of the Garber-Wellington Aquifer.

Another potential management vehicle for the Garber-Wellington would be a regional water distribution district. This type of district is created pursuant to 82 O.S. Supp. 1972, §§1266 et seq. A regional water distribution district is established by a filing of a petition with the district court in any of the counties affected containing one hundred or more qualified voters who are landowners in the county wherein a reservoir is to be located. At present time, the only areas in Oklahoma in which regional water distribution district may be created are the counties of McCurtain, LeFlore, Pushmataha, Choctaw, Atoka, Pittsburg, Latimer, Coal, Johnston, Pontotoc, Bryan, and Hughes, insofar as the stream systems of the Mountain Fork River, Glover Creek, Little River, Kiamichi River, Muddy Boggy Creek and Clear Boggy Creek are concerned. While at first it is apparent that the Garber-Wellington Aquifer is not contained within these counties, as earlier indicated, minor statutory amendments could alter this limiting factor and allow for the use of this type of district in the Garber-Wellington Aquifer area.

As with the other types of districts, the creation of the regional water distribution district requires a hearing before the district court to insure that the statutory requirements for the creation of a district are met and that the proposed district will promote the general welfare of the state of Oklahoma and be conducive to the purposes of the act. Following the creation of a district, a Board of Directors is impaneled, and certain powers are vested in the Board of Directors. These powers include not only the acquisition of water rights, but also the power to maintain and operate, acquire, own, hold, and dispose of plants, buildings, works, machinery, supplies, equipment, apparatus, facilities and transportation and distribution lines, equipment or systems necessary to transport, distribute, sell, furnish and dispose of such water. These districts are also empowered to borrow money and otherwise contract indebtedness, to make any and all contracts necessary or convenient for the exercise of the powers of the district to fix, collect rates, fees, rents, and other charges for water and any other facilities furnished by the water district, and to do and perform all lawful things and acts as may be necessary, convenient and appropriate to effectuate the purposes for which the water district is organized.

Another alternative for effective management of the Garber-Wellington Aquifer is through the Oklahoma Water Resources Board.

The Oklahoma Water Resources Board is given the power under present Oklahoma law, as it relates to the use of ground water and the development of the various ground water aquifers (including the Garber-Wellington Aquifer), to administer several provisions which are quite useful in ground water management. In general, these provisions encompass statutes concerning spacing orders, well location exceptions, metering of wells, the unitization and communitization of land for water production and also special statutes concerning the development of wells within municipalities, as well as regulations concerning licensed water well drillers.

Oklahoma law provides the Board with the authority and discretion to order such proper spacing of wells as is necessary to the formation of an orderly system of withdrawal of water from a basin or subbasin. This orderly system of withdrawal of water is to be related to the allocation of water to the land overlying the basin or subbasin. However, it should further be noted that this statute, and the effect it has on ground water law, is limited somewhat by a 1977 Attorney General Opinion. This Opinion held that the Oklahoma Water Resources Board did not have the authority to set mandatory well-spacing prior to completion of a hydrologic survey and allocation of the ground water to the land overlying the basin or subbasin. Op. Atty. Gen. No. 77-305 (February 22, 1978).

The information needed for the hydrologic survey and determination of equal proportionate share required prior to the

Board's having authority to well-space will be provided by the study of which this report is a segment. Thus, upon completion of this survey, the Board could well-space should it be determined appropriate and necessary to properly manage the Garber-Wellington Aquifer.

Presumably in connection with the well-spacing statute, as well as the general statutory requirement that wells only be drilled at permitted locations, the statute dealing with location exceptions appears to be permissive and discretionary with the Board. Before that statute comes into effect, it must be shown that to require the drilling of a well at the prescribed location would be inequitable or unreasonable. If the Board finds that to require the drilling of a well at such a location is inequitable or unreasonable, a location exception may be granted and the permittee may be allowed to complete the well at a location other than that previously approved under the permit.

Also for the protection of the aquifer and the permit holders having the right to withdraw water therefrom, Oklahoma statutes authorize the Board to require that water wells be metered. The statute imposes the requirement that the meters, approved for utilization by the applicant, be placed under seal, subject to reading by the agents of the Board at any time. This statute only comes into play under present law when a request is made by the majority of the landowners residing within a basin or subbasin. Therefore, it should be noted that for the Board to require metering of new wells in the Garber-Wellington Aquifer, a request would have to be filed bearing sufficient signatures to constitute a majority of landowners residing within the basin (Garber-Wellington). This would require many thousand signatures. However, when weighing the burden imposed to require metering against the total expense to the landowners and permit holders throughout the entire basin for the installation and maintenance of the meters, the Legislature apparently felt this requirement was not unreasonable. Nevertheless, consideration should be given to the propriety of making metering, where appropriate, more readily available as a management tool than presently provided through possible statutory revision. The Board is also empowered to require the applicant to report the readings of such meters at reasonable intervals. This statute may be utilized to insure that the amount of water being withdrawn from a given well or number of wells is commensurate with the amount allocated under the permit or the equal proportionate share established pursuant to hydrologic surveys.

There are also provisions of the Oklahoma Ground Water Law whereby the owners of land and the Commissioners of the Land Office are authorized to unitize and communitize lands for the purpose of production of water therefrom. This statute is limited by the proviso that the production of water therefrom shall not exceed the maximum annual yield of said land.

The Oklahoma Ground Water Law has established certain requirements for the use of water from platted lands by a municipality. Pursuant to §1020.21 of Title 82, a municipality is given the authority to regulate or permit the drilling of domestic and industrial water wells within the corporate city limits. The law requires that in order for the city to use the water allocated to platted land within its corporate limits, the municipality must be able to do the following:

1) Make water available to the residents of the platted land,
2) Obtain a permit from the Board,
3) Locate the wells on the platted land, and
4) Locate the wells not less than six hundred (600) feet within the municipal city limits.

As a further precautionary measure, to insure protection of the ground water and the ground water aquifers themselves, the Board is authorized to issue licenses to commercial well drillers in the State of Oklahoma. The statutes require that all persons engaged in the commercial drilling of wells for fresh ground water in the State must make application for and become licensed with the Board and file a bond with the State of Oklahoma of not less than five thousand dollars ($5,000) conditioned upon compliance with all the laws of the State and rules and regulations of the Board. This well drillers licensing statute also provides a requirement that the well drillers keep a log of each well drilled and certain pumping test data, which may be required to be submitted to the Board periodically. This information to be provided by the well drillers is very useful in the management and protection of the aquifer and can provide tremendous insight into the development of the aquifer as a whole.

CONCLUSION

Based upon a comparison and analysis of the available framework for best management of the Garber-Wellington Aquifer, it appears that the best management tools are already in existence. The current Ground Water Law with its management and protection provisions directed to the Oklahoma Water Resources Board provide the bulk of needed authority. Management and protection of the Garber-Wellington through greater use of the Board's existing authority is recommended not only because of the Board's established power and statutory authority but also because of its long-standing commitment to the goals and objectives of good management. In addition, use of the Board for management purposes with the Oklahoma Ground Water Law would not necessarily require any substantial amendments to existing law, and further would not require creation of any new entities or districts to address the problems and situations encountered in local management of the ground water. It would therefore appear that the best way to protect, develop and manage the Garber-Wellington Aquifer would be to fully utilize the metering, well-spacing and the other existing Ground Water Law provisions to accomplish the goals desired by local management entities and citizens.